INDEXED.

International Marine Engineering

OCTOBER, 1911.

PROGRESS OF THE DIESEL ENGINE IN MARITIME WORK.

BY J. RENDELL WILSON.

Lord Furness, the head of Furness, Withy & Company, Ltd., when he publicly gave out that his firm had placed an order for a 3,000-ton vessel to be driven by oil engines of the Diesel type, stated that to-day we are face to face with a development that will revolutionize the methods of propulsion in shipping. Of this there can be little doubt, so rapid has been the development of the crude oil-consuming marine internal-combustion engine. What were considered merely wild dreams five years ago are now solid facts, and many oceangoing craft are already in active service, and by the end of the year these will be joined by small transatlantic liners, which are now in course of construction in Continental yards.

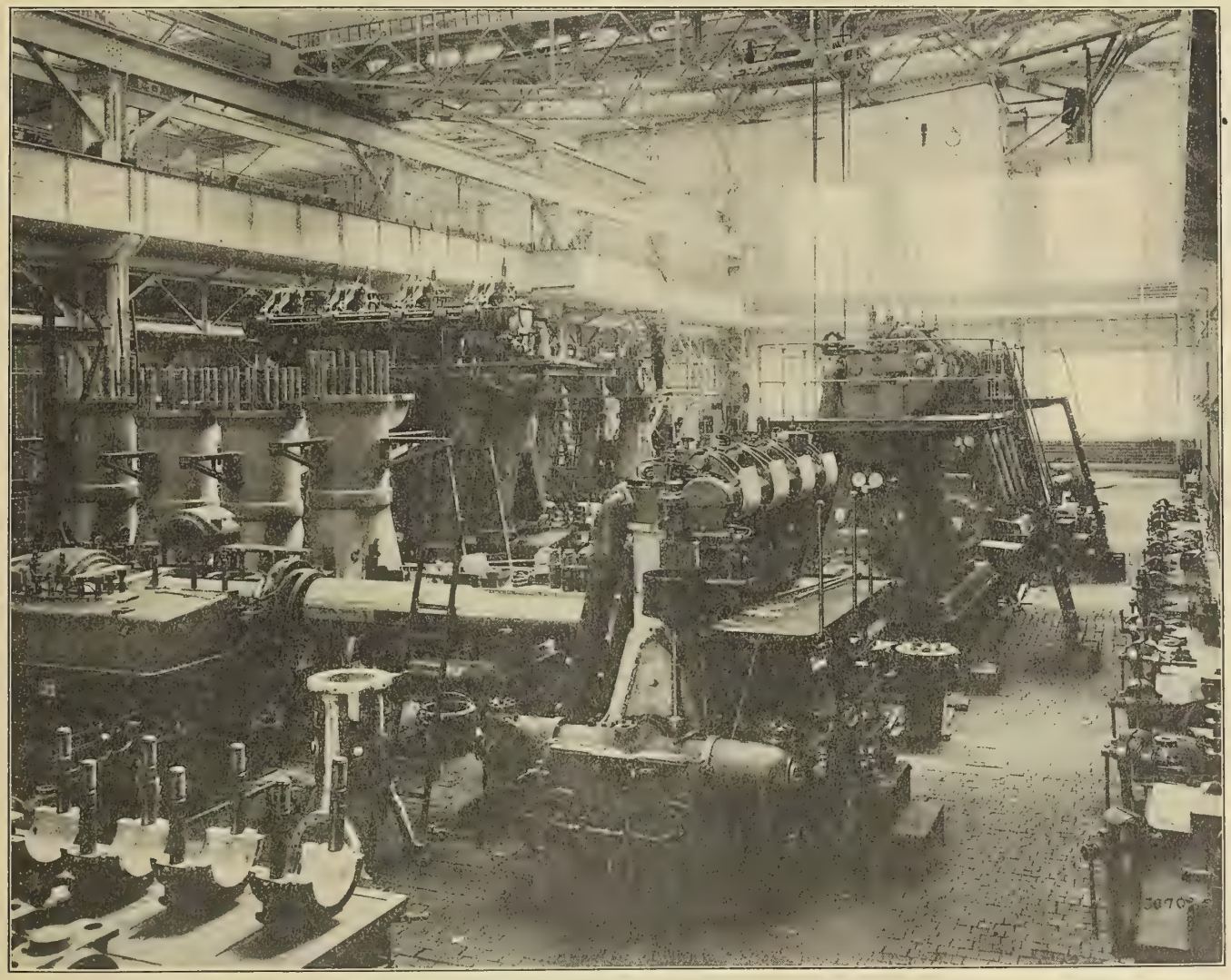


FIG. 1.—MARINE DIESEL ENGINES UNDER CONSTRUCTION AT THE WINTERTHUR WORKS OF MESSRS. SULZER BROS.

ADVANTAGES.

One of the principal claims of the Diesel-type engine is, of course, the great saving on fuel costs. Against this it has been argued that, after a certain number of such vessels are on the water, the price of oil will increase to the extent of rendering them more expensive to run than their

steam-engined sisters. This is a fallacy, or misstatement, to which no shipowner should give heed, as oil is distributed over a very wide area, probably over a wider area than coal. When the demand comes there will be a short disturbance in the market, and hundreds of new oil companies, good and bad, will be formed, and more oil fields opened up, as was the case with rubber recently. At present the flow of oil at the various great oil fields is far in excess of the demand, despite the enormous quantity of refined oil consumed.

FUEL.

Even were the price of oil fuel to increase, fuel charges are but a small item in the advantages of the heavy oil in ships. Oil being carried in the double bottom of vessels, the coal bunker space, and the boiler and condenser space saved enables the same amount of cargo to be carried with a great reduction of tonnage. This means smaller harbor dues. Again, stokers are not required, a considerable saving in the wages and food bills, and their quarters can be given over to cargo space, again increasing the earning powers of the vessel on the same tonnage. When the ship is in harbor, "oiling" is accomplished by simply running flexible piping aboard, and the fuel tanks filled in a short space of time. Here, again, much manual labor, time, and consequently expense, are saved; also no time is wasted in cleaning up ship, as is the case after coaling operations.

A few years ago the large passenger vessel *Uto,* in service on Lake Zurich, had her steam machinery replaced with a 150-horsepower Sulzer-Diesel motor. Originally she carried 150 passengers; but since the alteration she has been licensed for 200 passengers, so great was the saving of space. Naturally this made an enormous difference in her earning powers, and tends to show at least one advantage of oil engines, not to mention the many others.

So it will be seen that there are more points in favor of the internal-combustion engine than against.

PROGRESS ON THE CONTINENT.

Continental engineers realized these facts long before other nations, consequently they are far ahead, and the experimental stage with them is past. Already the Diesel-type motors in the Russian navy and mercantile marine aggregate 23,000 horsepower, composed of about fifty engines. Among the more notable firms engaged in large marine heavy oil-engine construction must be mentioned Fried Krupp, of Kiel-Gaarden, Germany; Sulzer Bros., of Winterthur, Switzerland; Carel Frères, of Ghent; Aktiebolaget Diesels Motorer, of Stockholm; Maschinenfabrik Augsburg, Nurnburg, Germany; Schnieder et Cie., of Paris; Société des Moteurs Sabathé, of St. Etienne, Paris; Société des Ateliers de La Loire, France; Nederlandsche Fabriek van Werktuigen en Spoorweg Materieel, of Amsterdam; Société Anon. John Cockerill, of Seraing, and Hoboken, near Antwerp; Burmeister & Wain, of Copenhagen; Chantiers & Ateliers Augustin Normand, of Havre, and the F. I. A. T. Company, of Turin. All these firms have already constructed marine oil engines up to 1,000 horsepower, and several have engines of 12,000 horsepower going through the shops, notably the F. I. A. T. Company, M. A. N. and Krupps.

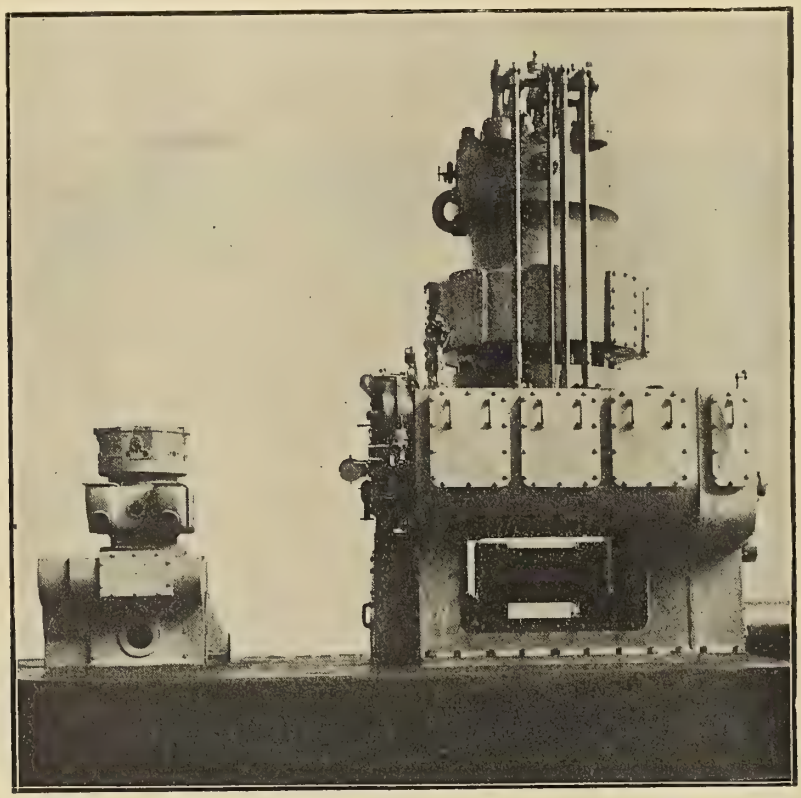


FIG. 2.—15,000-HORSEPOWER, SINGLE-CYLINDER CAREL-DIESEL MARINE OIL ENGINE.

DEVELOPMENT IN GREAT BRITAIN.

The launching of several large ships of this class right under their very noses awakened British engineers to serious consideration, and about thirty firms are now deep into the problem. On the other hand American marine engineers are only beginning to show signs of progress in this direction. It is time the United States government gave the necessary impulse by fitting a small warship with Diesel motors. The British Admiralty have already moved in the matter, and have publicly placed an order for an internal-combustion engined torpedo boat destroyer with Messrs. John I. Thornycroft & Company; while there can be little doubt that Messrs. Vickers, Ltd., is (in secret and at its own risk) building an eight-cylinder engine of 12,000 horsepower to be fitted, in conjunc-

tion with steam engines, in a battleship. Vickers is, it is understood, benefiting by the experiences of Carel Frères, on whose license it is working, and the illustration, Fig. 2, shows the single-cylinder 1,500-horsepower engine on which the design was based. This engine stands about 17 feet high, and has a bore of about 40 inches. It is of the four-cycle type with overhead valves. The high and low-pressure compressors are arranged by the side of the cylinder, but are not shown in the photograph for obvious reasons. The makers are bound by agreement with their licensees not to divulge any information, therefore further details cannot be given. The smaller engines to the left of the illustration are partly finished castings of a 250-horsepower set.

Among other British firms actively taking up the new industry are: Richardson, Westgarth & Company, of Hartlepool; Barclay Curle & Company, of Whiteinch, Glasgow; Brazil Straker & Company, of Bristol; J. White & Company, of Cowes; Gardners, of Manchester; Swan, Hunter & Wigham Richardson, Ltd., of Newcastle-on-Tyne; Beardmore Bros., of Dalmuir; Palmer Bros., of Jarrow; Babcock & Wilcox, of boiler fame; Mirrless, Bickerton & Day, of Stockport; Westinghouse Brake Company, and Willans, Robinson & Co. Messrs. Barclay, Curle & Company is building a 7,000-ton motor vessel for the East Asiatic Petroleum Company, and Richardson, Westgarth is constructing an engine of 1,000 horsepower for the 3,200-ton ship under construction by Sir Raylton Dixon & Company for Furness, Withy & Company, referred to by Lord Furness; while Messrs. Swan, Hunter & Wigham Richardson, Ltd., is building a 400-horsepower marine motor based on the experience gained with the Polar-Diesel engines of *Toiler*.

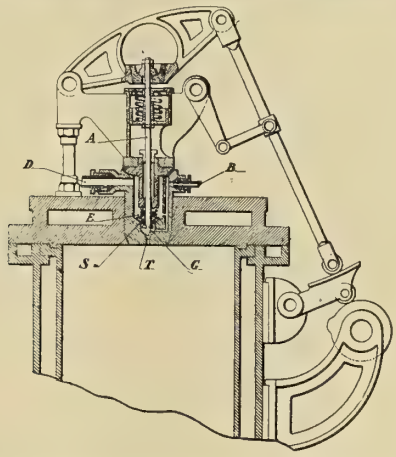


FIG. 3.—FUEL IGNITION ARRANCEMENT OF A 500-HORSEPOWER SABATHÉ MOTOR.

CONSTRUCTIONAL PROBLEMS.

Many are the problems and difficulties that face builders of large marine heavy oil engines, the conditions at sea being vastly different from the requirements of land installations, especially in connection with the government arrangements. Perfect castings of a fine grain iron are required for the cylinders and pistons, in addition to very careful machining. It has been found that mechanics accustomed to constructing steam locomotives make the best fitters and turners for Diesel work, as being used to working to a very delicate gage. Regarding the cylinder castings, the chief problem is that, while the necessity for cooling the walls demands thinness, strength demands thickness, as the casting has to stand internal pressures that may be anything from 400 pounds to 1,000 pounds per square inch. This pressure is, of course, not applied gradually, but in quick succession, about 100 to 200 times per minute. Strains of this nature demand all the designer's care, and a compromise has to be effected. Water-cooling the pistons is another difficulty, but in one or two cases this trouble has been ingeniously overcome; with one engine this has been avoided by cooling the pistons with lubricating oil. Of course, cooling is partially effected by the scavenging air, which with all two-cycle engines is blown through the cylinders at the bottom of every stroke. With the double-acting class of engine greater difficulties arise, as stuffing-boxes to stand enormous pressures under heat of over 500 degrees C. have to be made, and a suitable packing found; also the piston rod must be hollow and water-cooled by swivel-jointed water pipes or telescopic tubing. Propeller racing in rough weather can be guarded against by efficient governing, or by fitting a heavy fly-wheel; also the very high pressure is a factor against the engine suddenly picking up excessive speed. However, most of these worries have now been satisfactorily overcome

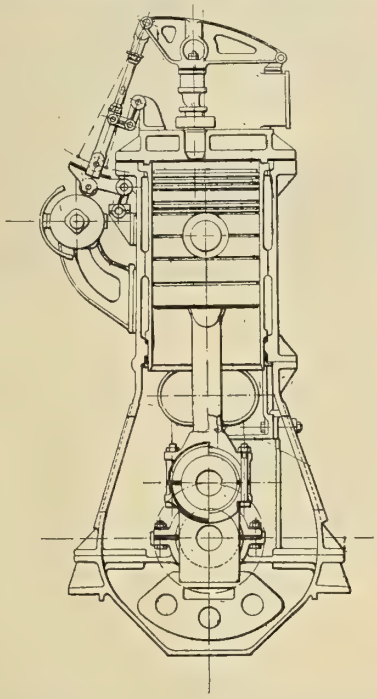


FIG. 4.—SECTIONAL DRAWING OF A 500-HORSEPOWER SABATHÉ MOTOR.

by Continental engineers, and I am enabled to give short descriptions and illustrations of the principal marine engines.

TYPES OF ENGINES. THE SABATHÉ.

A serious rival to the Diesel engine is to be found in the Sabathé crude oil engine, which has several distinctive features. Of the four-cycle type it is essentially a marine job, and the center of gravity is lower than is the case with the majority of engines of the Diesel variety. This, by the way, also seems to be a feature of Krupp engines. There are six cylinders, cast in pairs, each 13¾ inches diameter by 13¾ inches stroke, and 500 horsepower is developed at 400 revolutions per minute; but when required the revolutions can be reduced to 100 with excellent results. The cylinders are lined with steel, and the pistons, which are not water-cooled, are each fitted with four broad, white metal rings in addition to the ordinary cast iron rings, which obviates any frictional trouble likely to arise from the steel walls. The top of the piston is concave, giving a large, efficient combustion area.

Air for starting and fuel injection is provided by a three-stage compressor, which delivers the air at 800 pounds per square inch, and which is driven off the forward end of the solid machined six-throw crankshaft, as are the water circulating and lubricating pumps. The fuel pumps, of which there are six, are driven by eccentrics off the horizontal shaft,

which can be seen about 18 inches above the crank case doors, and a link motion gear alters the position of the fulcrum of the driving arms for varying the speed or shutting off the fuel feed. Regarding the fuel injection arrangements, there is a double valve in the center of the cylinder head, allowing the fuel to be sprayed directly onto the piston (Fig. 3). The needle valve (*G*) and the poppet valve (*S*) are kept on their

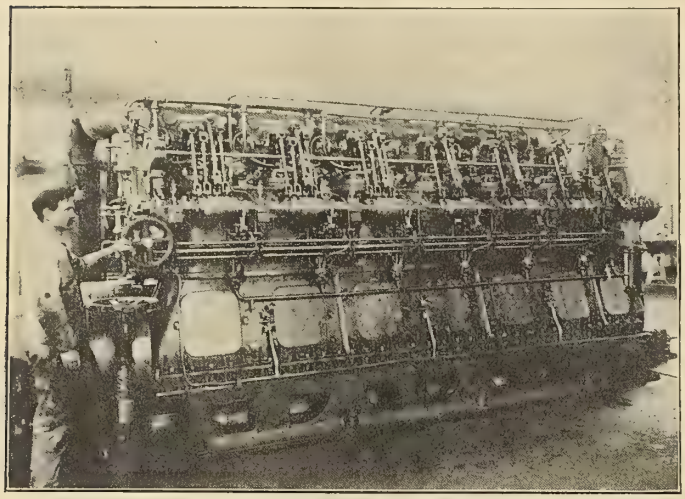


FIG. 5.—A 500-HORSEPOWER SABATHÉ CRUDE OIL ENGINE, BUILT FOR A FRENCH YACHT.

seats by springs, the valve (*G*) being lifted by a rocking lever and a cam, while the valve (*S*) is raised by a collar (*T*), which is secured to the needle valve, so that as the latter opens to a certain extent the valve (*S*) is lifted. This system allows of a small quantity of fuel only being injected into the combustion chamber at low speeds. Fuel consumption, I may say, has been brought as low as 0.4 pound per horsepower-hour of residual oil, the consumption of any engines of the Diesel type being not lower than 0.42 pound. The above engine was built for a French yacht.

THE POLAR-DIESEL.

It is not generally known that the Aktiebolaget Diesels Motorer, of Stockholm, makers of the Polar-Diesel motor as fitted aboard the *Toiler*, are one of the pioneers of marine Diesel work. This firm, by the way, recently removed the steam machinery from Dr. Nansen's Arctic exploration ship *Fram* and installed a 150-horsepower Polar-Diesel motor for the Amundsen Antarctic expedition. Their engines are of the two-cycle type, and usually have six cylinders, four working and two maneuvering. The forward of the latter contains a compressor, which contains a big storage cylinder charged to about 150 pounds per square inch, and this is utilized for starting purposes, supplying air through a reducing valve to both the maneuvering cylinders. As the working cylinders do not take up the load until the engine has made several turns, they pick up very easily. The maneuvering cylinders are, of course, double acting, and they also supply scavenging air at 5 pounds per square inch. Each of the working cylinders is equipped with a separate adjustable fuel pump. The exhaust and air scavenging ports, on opposite sides of the cylinder, are uncovered by the piston towards the bottom of the stroke, the piston head being so shaped as to ensure complete scavenging. In the cylinder head is the fuel injection valve, which is operated by a rocking lever, actuated by an overhead cam shaft driven off the crankshaft, by a perpendicular shaft and skew gearing, at engine speed. An interesting and noteworthy feature is that each cylinder is fitted with a hand-controlled relief valve for use if the engine has stopped with a working piston at the top of the stroke, as the admission of high-pressure air at such a moment would put heavy strains on the big ends and main bearings and also prevent the engine from turning. It is interesting to note that Messrs. Swan, Hunter & Wigham Richardson, Ltd., of Newcastle-on-Tyne, is constructing a 400-horsepower marine engine of similar design.

The following is a report, hitherto unpublished, of a test made by Mr. G. Bremberg, surveyor to the British Corporation Registry, of a 200-horsepower Polar-Diesel marine engine for the Southern Whaling and Sealing Company, of North Shields: This shipping firm is having the four-masted barque *Sound of Jura,* which was built of steel in 1906, installed with

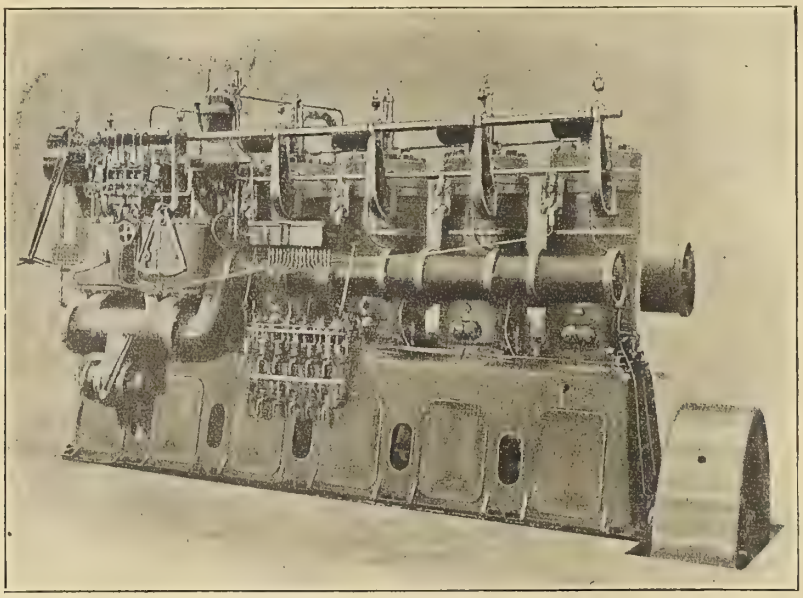


FIG. 6.—A 260-HORSEPOWER POLAR-DIESEL ENGINE. SPEED, 250 REVOLUTIONS PER MINUTE.

a 260-horsepower Polar-Diesel engine developing its rated horsepower at 250 revolutions per minute. She is 210.3 feet long by 35.6 feet beam and 19.5 feet draft. The firm is also having built, by Messrs. Smith Docks Company, two motor whalers, each 92 feet by 18 feet by 6 feet 10 inches, which will be fitted with Polar-Diesel motors of 200 horsepower at 280 revolutions per minute. The engine of which I give extracts of the tests is for one of the latter. After several hours' con-

tinuous run a consumption test of thirty minutes was taken with the engine at full load, the mean net load being 313 pounds. The engine averaged 282 revolutions per minute and developed 200 brake-horsepower, the fuel consumption being 42 pounds for the thirty minutes, and the consumption per brake-horsepower per hour was .42 pound. Another short test was made to obtain maximum power. With a net load of 225 pounds, and with the engine turning at 292 revolutions per minute, the effective brake-horsepower was 222; the exhaust gases were quite colorless, and no sign of warmth was noted in the bearings. Very satisfactory trials were also made of stopping, starting and reversing. Solar residue oil was used throughout the tests. The Aktiebolaget Diesel Motorer have supplied this type of engine to many firms, including the 320-horsepower tug *Jakut,* owned by Messrs. Nobel Bros. Naphtha Company, of St. Petersburg. But their first marine job was the 60-horsepower Polar-Diesel engine fitted in the 120-foot schooner *Orion,* owned by the Cassiopeja Shipping Company, of Stockholm. This was installed in the autumn of 1907. Among other vessels so fitted may be mentioned the 110-horsepower Polar-Diesel engines in the cargo vessels *Rapp* and *Snapp,* owned by the Alvar Shipping Company, of Stockholm.

With Polar-Diesel motors, which are of the two-cycle type, very nearly the same consumption of fuel as with four-stroke engines has been obtained, results quite unparalleled.

THE SULZER-DIESEL.

Another firm which has had much experience in this direction is Messrs. Sulzer Bros, of Winterhur, Switzerland, which is constructing the two 1,500-horsepower motors for the 6,000-ton liner now building at the Howaldt yard for the Hamburg-South America Company. This notable Swiss firm numbers among its achievements the equipping of the 1,000-ton passenger vessel *Romagna* with two 400-horsepower Sulzer-Diesel oil engines, which is now in service between Trieste and Ravenna, Austria. In the Sulzer engine, using oil fuel having a thermal value of 18,000 British thermal units per pound, the consumption at normal load varies from 0.40 to 0.55 pound per brake-horsepower hour, according to the size of the engine. This makes the running costs about 0.2 to 0.25 cent (0.1 to 0.15 pence) per brake-horsepower hour, basing the price of oil at $12.50 (50/–) per ton. This is, of course apart from lubricating oil; but the Diesel requires less lubrication than any other type of engine. Sulzer Bros. do not direct their energies to one particular type, but build both the two and four-stroke variety.

Fig. 7 shows the sectional drawings of a 400-horsepower Sulzer engine, which is of the four-cycle class. There are four working cylinders, the two others being the high and low-pressure compressors. Very great care has been taken in the construction, and the cylinders and piston rings are made of a special cast iron of fine grain, possessing exceptional wear-resisting qualities, the rings being turned with mathematical precision by a method ensuring equal radial tension, and are placed on the piston with polished faces. The connecting rod, crankshafts and pins are of very tough forged steel, while the bearing bushes follow the usual marine practice, being of white-metal lined gunmetal. Balance weights are fitted to the crankshafts. It will be noticed that the cylinders are water-cooled their entire length, and that the trunk-type pistons are exceptionally long, no crossheads and guides being fitted.

WERKSPOOR-DIESEL ENGINES.

These engines came into prominence in connection with the 1,900-ton motor tankship owned by the Anglo-Saxon Petroleum Company, of London, this vessel being propelled by a six-cylinder Werkspoor-Diesel engine of 500 horsepower, constructed by the Nederlandsche Fabriek Van Werktuigen en Spoorweg-Materieel, of Amsterdam. This boat has given such excellent results that her owners have already placed an order with the same engineers for an engine of 1,000 horsepower. *Vulcanus* is 196 feet long by 37 feet 9 inches beam and 10 feet 2 inches draft. She is built of steel, and her speed is over 8½ knots. Her engine is on the four-cycle principle, with six cylinders 15¾ inches diameter by 23 9/16 inches stroke, and 500 horsepower is developed at 180 revolutions per minute. As far as possible it has been built to conform with marine steam engine practice, and accessibility of working parts has been made one of the principal features of the design. The length is about 25 feet, and the height from the center of the crankshaft to the cylinder tops is 12 feet, while the weight is 42 tons without the piping, compressors, etc., the whole weighing some 85 tons. On Taraken residue oil at $9.50 (38/–) per ton the full speed consumption of fuel is .42 pound per brake-horsepower hour and .5 pound when at half speed.

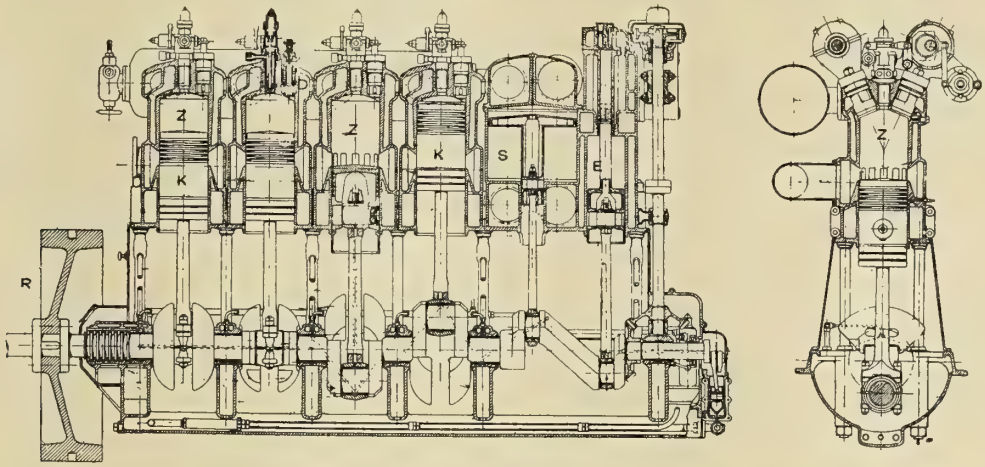


FIG. 7.—SECTION OF ONE OF THE 400-HORSEPOWER SULZER-DIESEL ENGINES FITTED IN THE 960-TON PASSENGER VESSEL ROMAGNA.

This engine differs from those previously described in this article, in that the compressors do not form part of the actual engine; but the engine is started by a two-cylinder, 50-horsepower auxiliary motor of the Diesel type, also a very heavy fly-wheel is fitted to prevent racing of the engine when the propeller lifts from the water in rough weather. The connecting rods are fitted with cross-heads and guides, allowing fairly short pistons. The 50-horsepower auxiliary drives a two-stage compressor for filling the air tanks, used for starting purposes and for maneuvering the main engine; but it also drives a centrifugal pump for discharging the liquid cargo, *Vulcanus* being an oil carrier. The compressed air tanks, of

which there are four, hold air at 300 pounds per square inch. On the starboard side of the main engine are the three-stage compressors used for fuel injection, the fuel being injected at 900 pounds pressure through a valve operated off the cam-shaft. The first-stage compressor is a single water-jacketed cylinder driven by links and a rocker off one of the cross-heads, while the second and third-stage compressors are in one casting, and are driven off another cross-head. The water-cooling pumps are also arranged on the starboard side between the compressors. Lubrication is by a Belliss & Morcom oscillating valveless pump actuated by an eccentric off the crankshaft, all oil, of course, passing through a filter before reaching the working parts.

The cylinders are cast in threes, and are fitted with cast iron liners. Unlike the Sulzer engines, which have exceptionally lengthy trunk-type pistons, the Werkspoor pistons, as before mentioned, are short, but are fitted with ten rings a

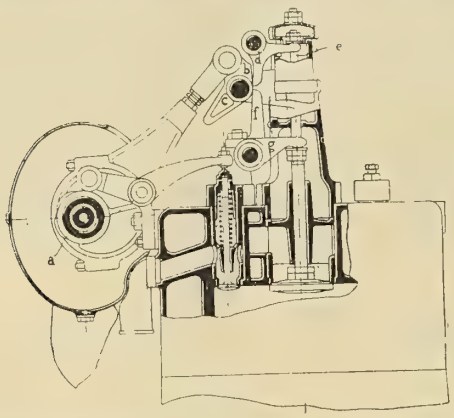


FIG. 8.—VALVE-GEAR ARRANGEMENT IN THE CYLINDER HEAD OF A 600-HORSEPOWER F. I. A. T. MARINE DIESEL ENGINE.

piece to prevent the compression escaping to the crankpit. As cross-heads and guides are fitted there is no side thrust to worry about; but the pistons are hollow and are cooled by a fan driven by friction off the fly-wheel, the current of air being admitted into the body of the piston by telescopic tubing —a noteworthy feature. There is no crankcase, but the cylinders are supported on I columns, the crank pit being covered in by large iron doors. By this arrangement the pistons and crankshaft can be taken out without disturbing the cylinders or valve gear.

Regarding the valve gear, this is arranged in the cylinder heads, and there are four valves to each cylinder—the inlet, exhaust, fuel and compressed air for starting, respectively. Each is operated by a cast steel rocker off an overhead cam-shaft running the entire length of the engine. Being about 25 feet long it is, of course, well supported by ample bearings. The engine is reversible, but space prevents describing the valve mechanism in detail, and I have already dwelt at length upon other parts. Briefly, however, reversing is carried out by bodily moving the cam-shaft, bringing another set of cams into action for the opposite motion. I must refer, however, to a recent voyage made by *Vulcanus* from Rotterdam to Hamburg and back. The distance between the two ports named is 735 nautical miles, the outward run from Rotterdam occupying just 100 hours. Her cargo for this voyage was 1,000 tons of benzine; the maximum speed for twenty-four hours was 8.5 knots, and the total fuel consumption 8¼ tons. The return run with 475 tons of water ballast was accomplished in 98 hours, maximum speed 8.9 knots. The cost of her fuel was about $10 (£2) per ton (although residue oil is obtainable at a lower figure), and her engines consume 1 ton of oil fuel for every 100 nautical miles that *Vulcanus* runs. Thus she can carry 1,000 tons of cargo 100 nautical miles with a fuel bill of $10, a saving of more than 50 percent over a steam vessel of similar cargo capacity, which is but one of the many advantages that steamship owners must eventually realize.

THE COCKERILL.

The system adopted by Messrs. Cockerill, of Seraing, and Hoboken, near Antwerp, for the engines under construction for the King of the Belgians' passenger vessel is entirely novel, and will give the ship excellent maneuvering qualities and economical slow-running powers; it is a practice likely to be generally adopted should it prove successful. The engine is divided by a clutch into two units or three or more cylinders, the forward half also being connected by another clutch at the fore end to a compressor, while the after half of the engine is coupled direct to the propeller. When slow speed is required by the navigator the forward half is disconnected and the compressor clutch thrown into gear, and the after part of the engine is run entirely on compressed air. This may seem complicated, but in reality is simple, and should prove to be very efficient.

M. A. N.

In International Marine Engineering of May last, the 3,000-ton auxiliary ship *Quevilly* was described and the two 300-horsepower M. A. N. (Maschinenfabrik Augsburg-Nurnburg) engines with which she is fitted were illustrated. Each engine has seven cylinders, six working and one air-compressing cylinder—not four working cylinders, as was stated in the May issue. This air-compressing cylinder is the high-pressure compressor for the fuel injection. A separate scavenging pump is attached to each cylinder at the lower half, virtually forming a cross-head guide for the connecting rod of the working cylinder pistons. All the lubrication and water-cooling pumps and the controls are mounted at the forward end of the engines. At the after end of each is a powerful clutch, used for disconnecting the propeller shafts when the vessel is under sail, allowing free rotation of the propellers. For starting purposes there are several air storage bottles, which are supplied by a compressor driven off an auxiliary engine, which also drives the electric light dynamo. On the test bed each engine developed 320 horsepower at 305 revolutions per minute on a fuel consumption of .462 pound of residual oil per horsepower per hour.

F. I. A. T.

The Fabrica Italiana Automobili Torino (F. I. A. T.), of Turin, is very busy with marine engines of the Diesel type, the largest being of 12,000 horsepower for the Italian navy, of which, of course, they are unable to divulge details. But their six-cylinder, 600-horsepower marine engine is of interest. It is of the two-cycle class, single-acting, and the rated horsepower is developed at 600 revolutions per minute. There are several decidedly novel features, one of these being that no separate pumps are fitted for air-scavenging the cylinder. This is arranged by double diameter pistons, the upper part being the working piston, and the lower portion acts as an air pump, while the air is retained in a reservoir formed in the crank-case casting, and supplied to the cylinders at the bottom of the stroke through two valves on the cylinder heads. These valves are actuated by cams on the cam-shaft that work the fuel injection valve and starting air valve, also on the cylinder head. The exhaust discharge is through ports uncovered at the bottom of the stroke.

For supplying the air for fuel injection and air for starting purposes there is a two-stage compressor at the forward end, driven off the crankshaft. The pumps for water-cooling and lubrication are grouped at the forward end, where they are driven off the crankshaft extension through a reduction gear. It is interesting to note that with F. I. A. T. engines difficulties arising from water-cooling the pistons have been avoided by oil-cooling the piston tops, which is found to be more successful than expected. The engine is, of course, reversible, and in the official trials by Italian naval officials the

reversing from full speed ahead to full speed astern was carried out with ease in five seconds.

GERMANIA MARINE ENGINE.

Messrs. Fried Krupp, the famous engineers of Kiel, Germany, have devoted considerable attention to the marine Diesel-type engine, and are the manufacturers of the Germania oil motor. This firm are building four 1,000-horsepower oil engines for the two 7,900-ton ships building for the German-American Petroleum Company. Through their courtesy I am enabled to illustrate a direct reversible, six-cylinder engine of 1,000 horsepower, which was lately built by them for the German government. It is of the two-cycle type, although Messrs. Krupp also make the four-cycle variety. The cylinders are divided into two units of three by the high-pressure compressor, while at each end is a low-pressure compressor, the former being used for fuel injection and reversing, and the two latter for air scavenging of the cylinders. Thus it will be gleaned that should one section of the engine break down the crankshaft can be uncoupled at the center and the vessel driven by the other half. The air and fuel injection valves, which are arranged in the cylinder heads, are driven off a horizontal overhead cam-shaft, actuated by a central perpendicular shaft and gearing, driven in its turn off the crankshaft. Nine large inspection doors are provided to the crankcase. As in the case of the Sabathé engine, the center of gravity is very low, there being no cross-heads, such as in the Werkspoor motor, trunk pistons being fitted. This engine is, of course, for naval work. The firm has just built an interesting motor vessel for the German government, which has been named *Mentor*. At present they are unable to divulge details, but from other information received she is of 75 tons, fitted with motors of 600 horsepower. Personally, however, I believe she is a much larger vessel, and equipped with oil engines of several thousand horsepower.

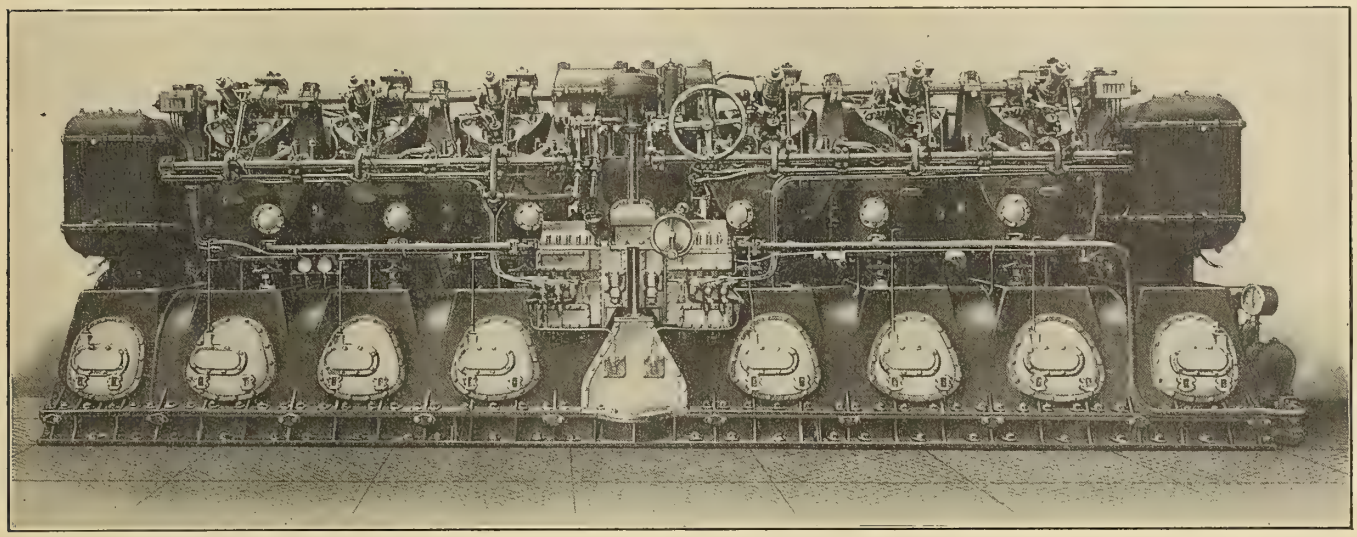


FIG. 9.—A SIX-CYLINDER, DIRECT-REVERSIBLE GERMANIA MARINE OIL ENGINE OF 1,000 HORSEPOWER, BUILT BY FRIED KRUPP OF KIEL.

SHIPS NOW IN SERVICE.

It is not generally known that there are already more than fifty large Diesel-engine ships actually in service. On the river Volga, Russia, the horsepowers of the various Diesel craft aggregate 23,000; two of these are gunboats—the *Kars* and *Ardagan*—each of 620 tons, which are equipped with motors of 1,000 horsepower. Messrs. Nobel Bros. Naphtha Company, St. Petersburg, owns half a dozen large motor ships, each of several thousand tons, while Messrs. Merkuljiff Bros. owns a vessel of 4,000 tons capacity, named *Djalo,* driven by two Diesel engines of 500 horsepower, and fitted with an auxiliary motor of 150 horsepower. Regarding other big motor vessels, *Vulcanus, Toiler, Quevilly* and *Cornelius* are already known to my readers.

VESSELS UNDER CONSTRUCTION.

Big motor ships known to be now building are too numerous to deal fully with here, and probably as many are building secretly or quietly, especially when one considers the fact that the Maschinenfabrik Augsburg-Nurnburg has nearly 100 large marine engines of this type on order, including a six-cylinder engine to develop 2,000 horsepower per cylinder, for German naval purposes—most probably for the center shaft of a battleship—but authentic information is unobtainable. However, I must make brief reference to the two 6,500-ton liners building for the Hamburg-American Line by Blohm & Voss and Burmeister & Wain, while the Hamburg-South America Company is having a 6,000-ton liner built at the Howald yard, Kiel, with engines by Sulzer Bros., Winterthur; Messrs. Burmeister & Wain is also building an 8,000-ton motor vessel of 2,000 horsepower for the East Asiatic Company, of Copenhagen, for service between Antwerp and Bangkok, Siam.

Again, the German-American Petroleum Company is having the 2,300-ton tank ship *Excelsior* fitted with two 900-horsepower Carel-Diesel type motors by the Reshertig Schiffsbau A. G. Of course, this paragraph is not given as *news,* but merely to draw attention to work in progress. Other craft may be mentioned. There is the 3,200-ton cargo vessel ordered by Messrs. Furness, Withy & Company from Sir Raylton Dixon & Company. Again, there is the 6,000-ton boat building on the Clyde by Barclay, Curle & Company, of Whiteinch; also the 1,000-horsepower tank ship for the Anglo-Saxon Petroleum Company, owners of *Vulcanus.* Also, there is the 600-ton revenue cruiser to be fitted with motors of 1,000 horsepower building for the Russian government by the Société Anon. Chantiers Navals Atelier et Founders de Nicolieff, and the Thornycroft oil-engined destroyer for the British Admiralty. Last, but not least, is the 1,000-horsepower Cockerill passenger vessel for the Congo, building to the order of the King of the Belgians. I could continue this list, but space forbids; however, the above will suffice to show that the future outlook is most promising, and shows strong indications that the Diesel type of oil engine will take a prominent place in the propulsion of ocean-going ships in the near future.

THE SUBMARINE VESSEL.

BY K. DIETZ.

(*Concluded from page 360.*)

In the determination of the value Q of the ballast water (see also page 358) it is to be observed that the amount Q_1, belonging to the external tanks, completely fills these in the under-water condition, and thus prevents the outer skin enclosing them from being bulged in by water pressure exerted from one side only. Similarly, also, the external oil fuel tanks must be kept full by pumping in water as the oil is consumed. During submerged runs it is desirable that the outer flooding valves be kept entirely open, in order that the hydrostatic pressures within and without the tanks may be kept as far as possible alike. For the determination of the amount of the rest of the ballast water Q_2, which is still maintained within the inner hull, it must in the first place be remembered that a variation of the percentage of salt contained in the water is accompanied by an increase of buoyancy. Should, for instance, during a blockade, a boat be submerged at low tide in the brackish water at the mouth of a river; that is to say, should the ballast tanks be filled with such brackish water (γ_2 = min. 1.0), a rapid equalization of the latter will not easily be effected even with the valves open, and the increase of the buoyancy $(D + d)\ (\gamma_1 - \gamma_2)$ = max. .026 $(D + d)$, due to the greater specific gravity of the water at a distance from the shore (γ_1 = max. 1.026 tons* per cub. m.), will have to be overcome by the taking in of additional ballast. Further, in the case of external fuel tanks with volume V, attention must be given to the circumstance that the oil, the specific gravity γ_0 of which is less than that of the ballast water γ_1, will, under water with tanks nearly full, continue to provide a maximum amount, $v(\gamma_1 - \gamma_0)$, of buoyancy, which must likewise be overcome by an increase of the ballast water. Now, since γ_0 = about 0.85 and γ_1 max. = 1.026 tons per cub. m., Q must amount at least to .026 $(D + d) + .176\ v$. There must also be a further amount of ballast sufficient to overcome any trim the vessel may have in the awash condition. It is, of course, incumbent upon the designer to arrange the ballast tanks in such a manner that, taken together, they trim the vessel horizontal when she is awash; but in spite of all care inclinations will always take place which will have to be adjusted. In the dimensioning of the ballast tanks it must further be borne in mind that all the structural parts of these and of the open erections, as well as all cavities in pipes passing through these latter, air storage flasks, exhaust pipes, cement, etc., also have a certain displacement which must be exactly determined by calculation and compensated by ballast water.

The pumping out of the ballast tanks after an under-water run is effected in the awash condition by ordinary centrifugal pumps, the air thereby flowing in of itself. In case of necessity, however, it must be possible, in the submerged condition, or in that of sinking as a result of damage, to pump out ballast when the slipping of detachable lead ballast has proved unavailing. For this purpose most of the pure submarine boats are provided with special high-pressure centrifugal pumps, which must be capable of overcoming the greatest hydrostatic pressure that will in practice be encountered. The air then flows from the inside of the boat into these tanks. In the case of submersible vessels, on the other hand, the emptying of the external tanks can be effected only by compressed air, and is not resorted to until the pumping out of the internal tanks has proved insufficient. For this purpose, indeed, large quantities of highly compressed air are necessary, the storage and constant replenishing of which within the vessel requires the presence there of new appliances. Special high-pressure air pumps are, as a rule, carried (output per minute = about .353 cubic feet of air at a pressure of 2,426 pounds per square inch). In case of necessity the compressor of the Diesel motor may also be pressed into the service. The use of compressed air for the emptying of the external tanks becomes necessary, because the outer skin is not strong enough to withstand great pressure, for water cannot be expelled till the air pressure within the tanks to be emptied is at least equal to the hydrostatic pressure without, so that the walls themselves (the outer skin) are actually not under one-sided pressure. Care must be taken, however, that when the boat rises on the emptying of the external tanks, the compressed internal air is able to expand and escape through the flooding valves.

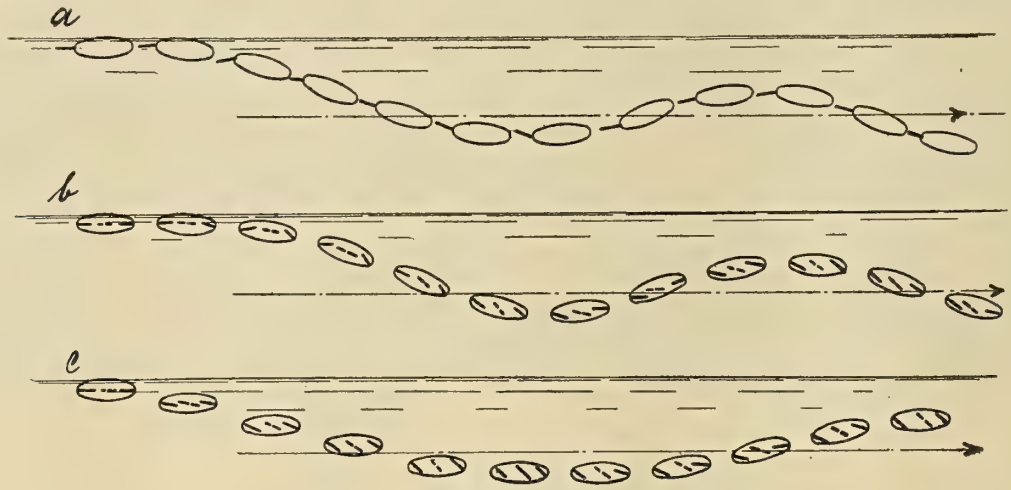


FIG. 6.

After the ballast water has all been taken in the transition from the "awash" to the "submerged" condition may proceed somewhat as follows: 1. By alteration of the trim (Figs. 6a and 6b). 2. By the sinking of the boat bodily downwards, the position of her axis remaining parallel with that in the awash condition (Fig. 6c). Boats with single pairs of horizontal rudders at their after ends can dive only in this way (Fig. 6a); but when a boat is fitted with several pairs of diving rudders it is possible for her to dive in either way. For a dive by means of alteration of trim the foremost pair of rudders are so adjusted as to press the fore body down beneath the surface of the water. The aftermost pair are meanwhile adjusted for "raising," so that the boat under the influence of the thrust of the propeller and of the rudder

* Of 1,000 kilogrammes.

moments, $T_a \times a$ and $T_b \times b$ (Fig. 3), both acting in the same sense, describes a gentle curve in the vertical diving plane. As soon as the desired depth has been reached the horizontal submerged condition is attained by the adjustment of the after-diving rudders to the downward pressing position as well as the fore ones. This method of diving is a very rapid one, because the speed of the boat is made use of to

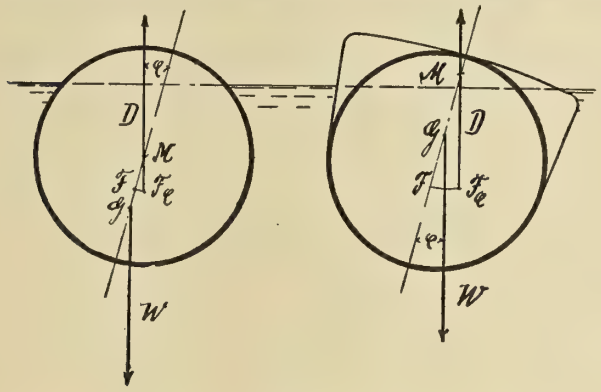


FIG. 7.

bring her down. It is also, however, the most hazardous, since, with the slightest inattention, dangerous depths may very quickly be reached. Greater angles of inclination with the horizontal than 10 degrees are accordingly carefully avoided. In the case of a dive with the axis of the boat kept at the "awash" inclination to the horizontal, which is often called a "dive on even keel," all the diving rudders are at the outset adjusted so as to produce downward pressure, and so handled that the vessel sinks with a fair degree of evenness. A dive in this manner takes rather longer than one made as above described, but it may be accomplished with greater safety, and, with a relatively inexperienced and unreliable crew, should always be preferred. If the rate of the reduction of the speed which accompanies the transition to the submerged condition were known, a simple theoretical analysis (Figs. 2 and 3) of this latter method of diving might be made, since the condition of equilibrium at any moment existing between the vertical components of the pressures on the diving rudders and the part of the surplus of buoyancy already overcome is of a purely static nature. In view, however, of the unknown deflection of the particles of water, due to the shape of the vessel, all existing theories relating to rudder pressures break down; here, again, we are thrown back on the results of experiments with models which, on account of the separation of the resistance of the vessel from that of the rudder blades required for calculation purposes, become very expensive.

After the intended depth of immersion below the surface and the "even-keel" position have been attained, the aftermost of several pairs of rudders, when so many are adopted, are fixed at the angle for diving, and the finer adjustment of the vertical steering is effected entirely by the help of the foremost pair. We have already seen that a state of suspension of a submarine boat is an impossibility, and in consequence every excess of rudder pressure causes an acceleration and a turning of the boat downwards, and every deficiency of pressure a like motion in the upward direction. It follows from this that during under-water runs the regulating diving rudders will be constantly in action; to enable her to maintain the intended depth of immersion the boat must constantly perform oscillations and stamping movements of more or less considerable amplitude. This tendency will be the more pronounced in boats fitted only with single pairs of diving rudders. In order to minimize these oscillations—that is to say, to give a better stability, of course, at the depth of immersion desired—hydroplanes are fitted abaft the diving rudders, but the large proportion of length to depth (max. $L : B :: 12 : 1$) is in particular design to give a certain steadiness in this direction. Further, the already-mentioned effect of the broad after-body on the course-stability also shows to advantage here. The center of mean distances of the greatest superficial extension of the boat in the horizontal plane, correspond-

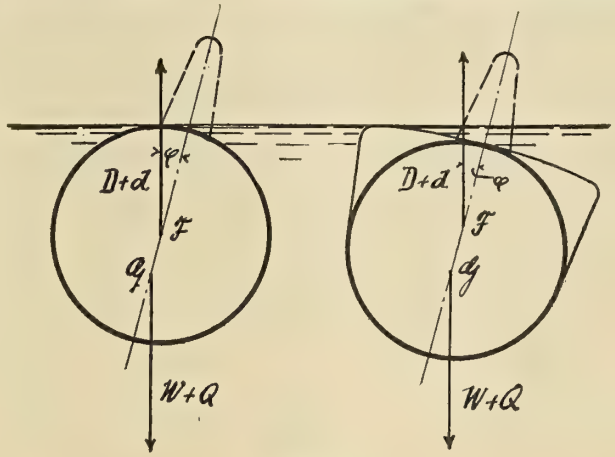


FIG. 8.

ing approximately with that of the waterline of greatest area, is thereby kept unusually far aft and unusually far behind the center of gravity of the vessel when this point assumes its ordinary position. On the assumptions that with a given trim under water the turning of the boat takes place about a horizontal athwartship axis through her center of gravity, and that

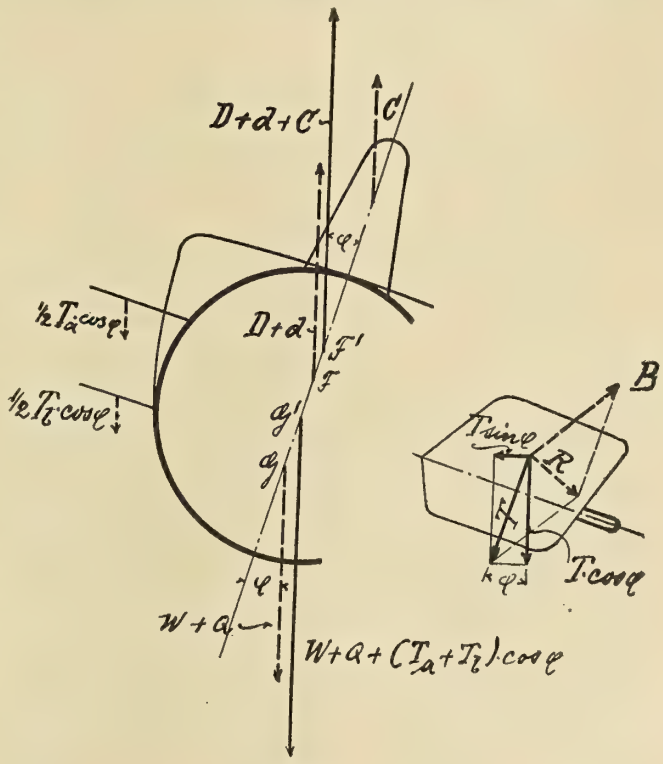


FIG. 9.

the resistance of the water to such turning acts approximately in the center of mean distances above mentioned, a moment tending to bring her back to her old course must be set up with every vertical deviation from the latter. If this center of mean distances lay at a point forward of the center of gravity, the tendency of the boat to turn a somersault would, under certain circumstances, be directly promoted thereby. The

influence exerted by the broad after part of the vessel towards the prevention of vertical oscillations is therefore to be ranked in importance with that of trim by the stern of a vessel steaming at the surface to prevent her from falling off sideways from her course.

When submerged, a submarine represents a system which approximates very nearly to a condition of equilibrium between forces acting in the vertical plane. Sudden disturbances, such as the firing of a torpedo, inclinations caused by the putting over of the vertical rudder, etc., may, with careless manipulation of the diving rudders, cause incalculable course-deviations in every direction, and this may suffice to show the difficulties of submarine navigation, impeded as it already is by the difficulties of obtaining bearings.

In the case of the large boats, at all events, the action of the increased inertia towards the prevention of alterations of trim

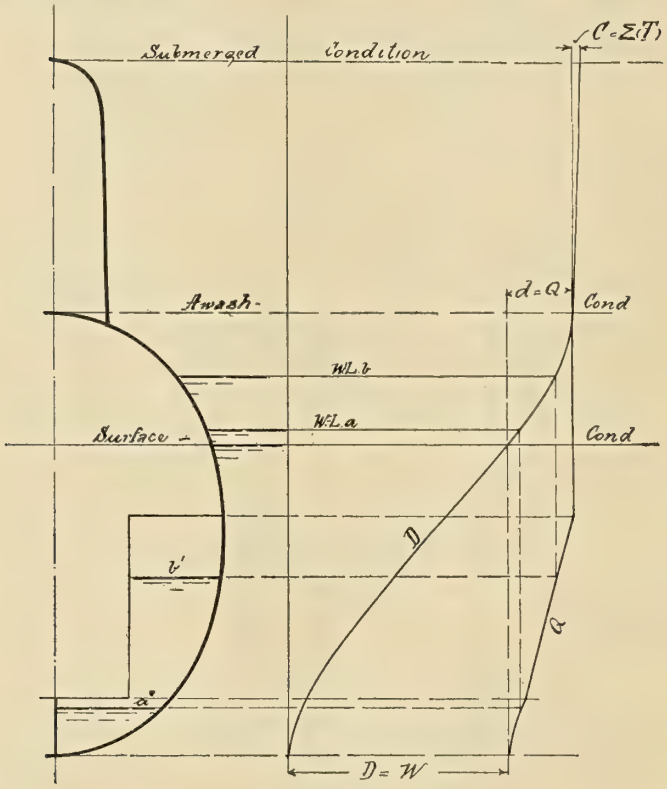


FIG. 10.

is agreeably in evidence. This was probably one of the reasons for the increase of the displacement of these boats beyond that formerly ruling. In view of the considerable cost for the construction and maintenance of the first experimental boats, the dimensions of these were, of course, kept very small; for dependence had in the main to be placed on the expensive purely electrical accumulator system for propulsion, even for surface runs. Since the systematic development and actual application of the submarine boat as a weapon of warfare, however, its displacement has increased. To this growth a limit of about 800 tons of surface displacement has now been set, chiefly because oil motors for the powers, which would, beyond this, be required, have not yet been built, and the necessary reliability in working with them would be missing, but also for the further reason that the deadweight of the storage battery, which always has to be carried, reaches quite unmanageable proportions. Here, also, however, experience has in general shown that increase of displacement brings advantages in almost every direction. In addition to the improvement of the course-stability and the action of the inertia in counteracting changes of trim, this lies in the considerable enhancement of the fighting value (speed, radius of action, necessary comfort and safety for the crew and increase of the store of spare ammunition) in the improved sea qualities accompanying the increase of reserve buoyancy and in the improvement of the stability.

The advantages of greater displacement are especially prominent in the submersible, which in itself already represents an important step in advance. For the magnitude of the reserve buoyancy of the submersible there is, properly speaking, no upper limit so long as the duration of the maneuver of submergence does not come in question. A lower limit, determined in relation to the resulting freeboard exists, however, and this is set by the extension of the stability conditions of a modern submersible as contrasted with those of a pure submarine boat. In general, these are very simple. During surface runs they do not differ in any way from those of an ordinary vessel. The stability of a vessel floating at the surface of the water is, as is well known, made up of a weight stability and a surface stability, the former depending on the height of the center of gravity G and the latter depending on the height of the center of buoyancy and on the alteration of form of the displacing body at inclinations from the upright (waterline stability); that is to say, on the lateral movement of the center of buoyancy F, occasioned by such deformation. As may be seen from Fig. 7 the older submarine boats, which swam on their circular-sectioned hulls even on surface runs, have, by reason of the arching up of their upper surfaces, very little water-plane stability, so that dependence must in the main be placed on the weight stability. It is advisable, therefore, in these boats to keep the center of gravity below the center of buoyancy, already in surface condition, so that a moment tending to careen the vessel does not at any inclination occur. In the submersible the case is different. Here the broad upper works give very considerable water-plane stability, and in order to attain reasonable stability conditions a position of the center of gravity above the center of buoyancy must, especially for surface runs, then be aimed at.

If J_b be the lateral moment of inertia of a waterline we obtain for the initial stability $M\,F = \frac{J_b}{v}$. Let us now consider the awash condition. If the surplus buoyancy be represented by the volume of the tower, the hull proper will already be below water. If the slight influence exerted by the tower, which is still above water, be neglected, we may set $J_b = O$, and also $M\,F = O$; that is to say, in the awash condition the metacenter coincides with the center of buoyancy. The water-line stability is herewith destroyed, and only the weight stability remains; that is to say, it is imperative that the center of gravity G lie below the center of buoyancy F ($F\,G = 250$ to 500 mm.). The same holds for runs in the submerged condition with both types of boat, but on account of the tower, *i. e.*, of the surplus buoyancy, the general center of buoyancy F' will rise somewhat higher, and, according to the vertical position given to the horizontal rudders and the varying vertical pressures on these, the general center G' of gravity resulting from $Q + W + (T_a + T_b) \cos \Phi$ (Fig. 9) will be subject to slight oscillations.

Such is the stability in the final conditions. In the intermediate state between the surface and awash conditions, however, it becomes complicated by the circumstance that the free surface of the water in the gradually-filling tanks, with its stability-reducing properties, has to be taken into account. In a pure submarine boat this is of small consequence, for, provided the center of gravity be not unduly raised by the water in the tanks, she is in a condition of absolute stability, with G below F. As a check upon the reduction of the stability, due to the free surface of the tank water, the method shown in Fig. 10 may be applied, the only assumption in which is

that all the tanks are run up simultaneously. The surfaces of the water in the tanks will then be at about the same height at each instance. By means of the displacement scale D and the filling scale of the tanks Q, it becomes possible for each external waterline a or b readily to determine the heights and breadths of the internal water surfaces (a' b') and the influence these exercise on the initial stability.

Exactly the same holds good for a submersible, on the assumption that the center of gravity is already below the center of buoyancy in the surface condition. Prominence is here assumed by the phenomenon that, after a certain point of time represented by the waterline c in Fig. 11 is reached, that

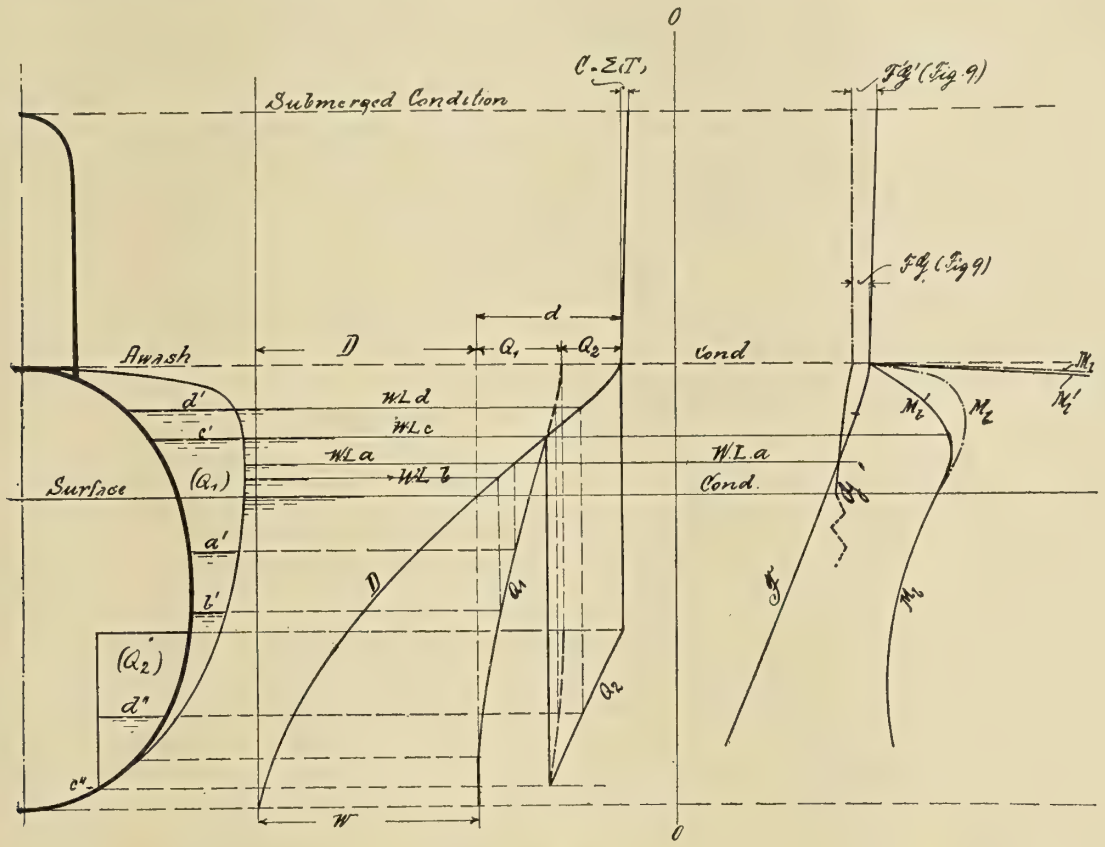


FIG. 11.

two free water surfaces in the tanks have to be reckoned with—that of the outer ballast water Q_1 and that of the inner ballast water Q_2—which may, for any external waterline, be obtained from Fig. 11 in exactly the same manner as for a submarine boat from Fig. 10. The stability-reducing influence of the ballast water between the surface and awash conditions is given for the transverse and longitudinal metacenters in the right-hand diagram of Fig. 11. The curves M_b and M_1 give the metacenters regardless of, and M_b' and M_1' these as affected by, the water surfaces of the tanks. For the longitudinal stability is also affected by these, and the longitudinal metacenter in the submerged condition again coincides with the center of buoyancy, so that below the water the longitudinal and transverse stabilities become exactly alike. It therefore is necessary to care for a sufficient degree of subdivision of the tanks in the longitudinal direction and the necessary wash-plates must in every case be provided.

Of special interest again are the stability conditions of a submersible in which the center of gravity is above the center of buoyancy in surface trim. In the submerged condition G must lie *below* F; during the running up of the tanks, then, the critical condition must at one particular instant occur in which the two centers coincide (W L a). This might be dangerous if the waterline stability were insufficient. It is absolutely necessary, therefore, and the height of the freeboard must be so arranged that the deck of the boat does not become submerged till a later instant of the awash period, so that a sufficient degree of waterplane stability is available at this critical time. It is also good practice to bring about the coincidence of the two points before the extreme waterline c (Fig. 11) is reached, so that there is then only one tank waterplane exercising a reducing influence on the stability. Fig. 11 gives, at its right-hand side, the suitable alteration of level of the two centers for the case assumed. F is the locus of the center of buoyancy above top of keel (to the external waterlines, set off from the vertical line O-O). G is the locus of the center of gravity. Waterline a is the critical one for the stability. It may at the same time be seen from the figure that the longitudinal and transverse stability are at their minimum in the awash condition; for the influence of the vertical diving rudder pressures T_a and T_b on the vertical position of the general center of gravity is, for the most part, less than that of the surplus buoyancy on the general center of buoyancy.

Hitherto the assumption has been made that the surfaces of the water in the tanks are "free." This is not, however, in accordance with the actual conditions. In regard to the stability, indeed, these are still less favorable, since they include a certain leakage through the valves, which have to stand open during the awash period. The ingress of the water is here greater at the side which is becoming submerged on account of the increase of the hydrostatic pressure. The leakage, however, can only be looked on as exercising a limited influence; for the flow through the valves will always be throttled to a considerable degree, so that for small inclinations the condition of free water planes above mentioned may practically be reckoned with. Of interest, also, is the circumstance that when the diving rudders are turned during an inclination of the vessel the vertical pressures are $T_a \cos \Phi <$

T_a and $T_b \cos \Phi < T_b$ (Fig. 9); that is to say, the rudders must then be turned to a greater angle. If the inclination of the boat were 90 degrees, no further diving could take place, and the boat would certainly come to the surface.

There is no difficulty in providing the necessary local and general strength required by a submarine boat. As was to be expected, the experiences obtained in the construction of ordinary vessels were, in the first designs, made use of. The early methods have latterly, however, been entirely discarded. The ordinary transverse and longtudinal structural arrangements are applied only to the erections outside of the hull proper, while the latter, when of circular section, has no inner framework except what is necessary for the seatings and brackets for the machinery and other equipment. The strong shell plating which is necessitated by the external hydrostatic pressure is, thanks to its circular form, itself so well able to resist longitudinal bending moments that nothing further is required. It results from this that the internal space is no longer cramped by projecting structural parts, and that the hull itself is evenly stressed; for, when frames were fitted, the resistance to external pressure, although very great in way of these, was, owing to the reduction in the thickness of the plating, considerably lessened between them. The great advantage possessed by the frameless hull, however, is that it can be built in sections, each of which in itself forms a completely welded-up length of tube. By this means the dangers of leakage at riveted connections are completely removed, and the circular form of the hull can best be kept true. The further experience appears here to have been obtained that, even when frames were fitted, no considerable amount of weight was saved, in spite of reductions that could be made on the shell plating. The only objections to the welding of the hull are that the process itself is very expensive, and that it is difficult, if not impossible, to check the quality of the work.

The stresses due to external pressure, which are applied only to the inner hull, the tower and the hatch casings, are accompanied by the ordinary longitudinal ones which are present in every vessel, and which are here subject to slight alteration only in connection with the diving-rudder pressures and the surplus buoyancy in the submerged condition. The first-named stresses reach their maximum in way of the largest diameter of the inner hull, and the others in general at a section at another point in the length. It is the affair of the designer to determine the section between these two which is actually subject to the action of their greatest resultant. The greater the depth of immersion assumed in the preparation of the strength-diagram the smaller will be the influence of the longitudinal stress, unvarying as the latter is for all depths. It must here not be lost sight of that the longitudinal bending moment also affects the more lightly built erections and the walls of the external tanks; in view of the riveted connections of these their strength conditions must receive special attention.

For the determination of the stress to which the hull proper is subjected by the external pressures, one of the many available empirical formulæ may be applied. The approximation to the actual conditions hereby obtained is sufficiently accurate, because the variation of the contour of the inner hull of a submersible, in particular, from that of a spindle-shaped body, to which these formulæ in general apply, cannot yet be taken into account. If, however, the sections of the inner hull are not circular, as in the case of the Italian *Laurenti* design, the method of determining the stresses adopted by Hurlbrink (Schiffbau, Annual No. IX.) may be recommended. In this the local stresses are also taken into account, but, above all, the point in each section of the inner hull under investigation at which the greatest transverse bending moment occurs, and which must therefore be most strongly stayed, is indicated.

The transverse strength of the inner hull receives considerable support from the presence of bulkheads in the hold. Formerly much uncertainty prevailed as to whether it was desirable to fit bulkheads into a submarine boat, because they prevented a good survey of the interior. As the displacement gradually increased this reason ceased to be in itself conclusive. The next step, therefore, was the fitting of light watertight bulkheads, the sole object of which was the localization of explosions or of gases which might be unpleasant to the crew. The tacit hope seems, however, to have been entertained that at shallow depths they would, in case of leakage, be able to withstand one-sided water pressure. In some recent boats, bulkheads would appear to have been fitted that are specially designed to resist one-sided pressure even at considerable depths of immersion.

The foregoing may serve as a general survey of the many theorems which come in question in the design of a submarine boat. The clearing up of the many doubtful points which still await complete theroetical and practical solution must be left to the future. These, however, are mostly of a minor description; the general problem of the submarine boat may be regarded as completely mastered.

Recent Development in Sea Transportation of Swedish Ore.*

BY J. JOHNSON.

The vessels employed in this trade (ore carrying) are nearly all tramp steamers, of which those which are especially built for the trade have a distinguishing feature—a special outfit of a large number of ordinary steam-hoisting winches. In the best-planned vessel of this kind the arrangement of hatches has enabled the cargo to be better distributed in order to reduce the straining effect on the ship. The discharge of ore is still done chiefly by manual labor, it being shoveled into ore bags, which are hoisted in the usual way and emptied in the chutes. Shoveling iron ore by hand is extremely laborious and not in keeping with the best-equipped loading ports. Naturally one's attention is turned to the latest system of discharging ores in the United States, but the condition of the American ore trade differs from that of Europe.

Iron miners in Sweden decided to try the Johnson-Welin system, which proved very satisfactory, and in the following year a vessel of about 8,000 tons dead weight was fitted with the same. The system is to sub-divide a steamer by means of transverse bulkheads, forming alternately bins for the cargo and discharging shafts. The vertical bulkheads do not extend to the bottom of the hull, but terminate about 7 feet from the tank top and are connected to the sloping bottom of the bins, the slope being about 42 degrees from the horizontal. The design further embodies wing tanks for carrying water ballast, and the tops of these tanks are sloping in order to convey the ore to the wing outlet chutes. This system dispenses entirely with all the hands on deck except the crane driver, the hoisting, slewing and tipping being done by one man on a platform on the crane, and the electric transmission of power lends itself admirably to the smooth and effective working of these cranes. Steam-heating pipes are fitted in the holds under the bottom of the ore bins, which prevent them from freezing when the ore is received covered with snow. The vessels so far built on this system are the *Vollrath Tham,* 8,000 tons; the *Sir Ernest Castle,* 10,800 tons. They were built by R. & W. Hawthorn, Leslie & Company, of Hebburn-on-Tyne. These two vessels during continued service have fulfilled all expectations of their owners, designers and builders.

* Abstract of paper read at the Jubilee Meeting of the Institution of Naval Architects.

FOR HEAVIER ARMOR.

BY SIDNEY G. KOON, M. M. E.

In connection with the re-designing, last year, of a dreadnought for a South American power, a curious result was obtained upon an investigation as to the best means to utilize increased displacement in adding to the armor of the ship. The vessel, as originally designed, carried a powerful battery associated with high speed, but the armor protection was the target for a great deal of criticism. For this reason it was decided to allow the designers an extra 1,000 tons of displacement, to be utilized, so far as possible, in strengthening the protective elements of the ship. And right here is where the difference of opinion set in; for one faction wanted to completely overhaul the design, expanding the vessel in every direction to accommodate the increase in displacement from 21,000 to 22,000 tons. The other side wanted to hold the design as it was, so far as possible, and to obtain the extra displacement by deeper immersion (a matter of 12¾ inches). As the controversy showed no signs of clearing away, the case was made the subject of an investigation, of which the following is a brief account:

The original design showed a waterline length of 510 feet, a beam of 87 feet and a normal draft of 28 feet (uniform), the block coefficient being 0.5916. The designed speed was 22 knots. The shaft horsepower of the propelling turbines was to be 33,000, based on an Admiralty coefficient (K) of 245½, in the well-known horsepower formula

$$H = \frac{D^{2/3}\ V^3}{K}$$, $D^{2/3}$ being 761 and V^3 being 10,648.

The battery included eight 14-inch guns mounted in pairs in four turrets, after the manner of the 12-inch guns on the United States battleship *Michigan;* twenty-four 5-inch guns in the battery; fourteen 3-inch semi-automatic guns on the superstructure, under the bridges and on the upper turrets, and four submerged tubes for discharging 21-inch torpedoes. The main items of weight are shown in the table, in the column headed *A,* that marked *B* being for the expanded ship, while *C* shows the weights for the ship more deeply immersed.

The armor protection, about which the whole controversy raged, included a belt amidships, 300 feet long and 12 feet wide, of which one-half was above and one-half below the normal water plane. This belt had a uniform thickness of 9 inches. It was continued to the bow and stern by a 12-foot end belt 5 inches thick. Diagonal armor, starting at the ends of the heavy belt and sweeping around the bases of the end-most turrets, was 12 feet deep and 6 inches thick. Above the main belt and diagonal was a citadel 11 feet high and 6 inches thick. The 5-inch guns were so located as to train over the upper edge of this citadel, and were further protected by 5-inch battery armor rising 5 feet above the citadel. The axial height of these 5-inch guns above the normal water plane was 18 feet. Barbettes for the heavy guns, 33 feet in diameter, were protected by 9½ inches of armor wherever exposed, and by 4 inches where behind other armor. The turrets had 11-inch face plates and 8-inch backs. The one conning tower was 12 inches thick.

The expanded design had a length of 519 feet, a beam of 88 feet and a draft of 28½ feet, the block coefficient of fineness being 0.5916, as before. With $D^{2/3}$ raised to 785, the new shaft-horsepower becomes 34,000 on the same Admiralty coefficient. The battery was identically the same. With the added weight allowable for armor it was found possible to increase the thickness of the main armor belt to 10 inches; of the diagonal and citadel armor to 7 inches; of the battery to 5½ inches, and of the exposed portions of the barbettes to 10½ inches.

In the design *C* the draft becomes 29 feet ¾ inch, and the block coefficient 0.5971. This was considered a little more difficult to propel than design *B,* and the Admiralty coefficient was accordingly reduced to 242¼, at which the shaft-horsepower figures out as 34,500. The battery is as before. The additional armor weight permits an increase in the main belt to 11 inches; in the ends to 5½ inches; in the battery to 7 inches, and in the barbettes to 11 inches. The diagonal and citadel armor are 7 inches, as in design *B.* Splinter protection in the battery, to the amount of 45 tons, was also added. The deeper immersion required the raising of the entire armor belt about 1 foot, but stability was ample to permit this.

Distribution of Weights.	A.	B.	C.	D.
Hull and fittings	8,400	8,800	8,450	8,428
Equipment and stores	1,065	1,100	1,070	1,070
Machinery and water	2,310	2,380	2,415	2,380
Normal fuel supply	1,650	1,700	1,725	1,700
Battery and ammunition	2,500	2,500	2,500	2,500
Armor, complete	5,075	5,520	5,840	5,492
Total	21,000	22,000	22,000	21,570

Details of Armor Weights.	A.	B.	C.	D.
Main belt	1,182	1,313	1,444	1,313
Belt at ends	464	483	507	464
Diagonal armor	315	371	371	368
Citadel, complete	1,012	1,181	1,178	1,178
Battery armor	301	332	421	331
Splinter shields	....	....	45	....
Barbettes	696	715	734	715
Turrets	780	780	780	780
Conning tower	80	80	80	80
Total armor	4,830	5,255	5,560	5,229
Backing and bolts	245	265	280	263
Totals	5,075	5,520	5,840	5,492

In the general distribution of weights it will be seen that the expanded ship *B* requires 400 tons additional for hull weights, where the deepened ship *C* takes an increase of only 50 tons. The weights allotted to equipment and stores show only moderate changes, due in part to the additional horsepower and in part to increased general size. The weight of machinery and water (for steaming purposes, including condensing water actually in the condensers and pipes) follows the horsepower directly, so also does the fuel supply (equal steaming radii being required). The battery was not changed at all.

In the expanded ship the turrets are all located in the same position, relative to the center of length, as are those in the other two designs. This means that the length of main armor belt remains constant, and the only required additions to armor weights, as a direct consequence of augmented size, come from the "end belt" 9 feet longer than in *A* and the diagonal armor on water plane and citadel, due to an addition of 1 foot to the ship's beam (16 inches added to length of diagonal armor at each end of vessel). From these three sources the necessary weight increments amount to about 28 tons, which would have increased the armor weight of *B,* on the schedule of thicknesses adopted for *A,* to 5,103 tons. We have thus obtained from the additional 1,000 tons of displacement in *B* a gain in armor of 5,520 — 5,103 = 417 tons, or 41.7 percent of our added displacement. In *C,* on the other hand, no changes in dimensions call for additional armor weight, and the full difference, 5,840 — 5,075 = 765 tons, or 76.5 percent of the added displacement, becomes available for increased armor protection.

Had the armor schedule in *B* been expanded from that of *A* on the same ratio of expansion as the dimensions, but without increasing the thickness, the required armor weight on *B* would have been 5,075 × 785 ÷ 761 = 5,235 tons, which would have permitted us a gain of only 5,520 — 5,235 = 285 tons, or 28.5 percent of our added displacement. This would, of course, have presupposed a slightly wider and longer heavy armor belt, and other dimensions accordingly. Such an arrangement would have deprived us of 132 tons, or nearly one-third of our actual 417-ton gain.

One interesting point brought out at the discussion on these

several designs, which, after all, were not used, but were later abandoned in favor of a heavier and somewhat different one, was that a ship with all the advantages of *B* could be designed after the manner of *C*, but with a considerably smaller displacement addition than the 1,000 tons allotted. This vessel, called *D*, is also shown in the table. The estimated difference in cost between *B* and *D*, which is about $175,000 (£36,000), would cover the cost of a small submarine.

FREIGHT TRANSFERRING MACHINERY AT ANTWERP.

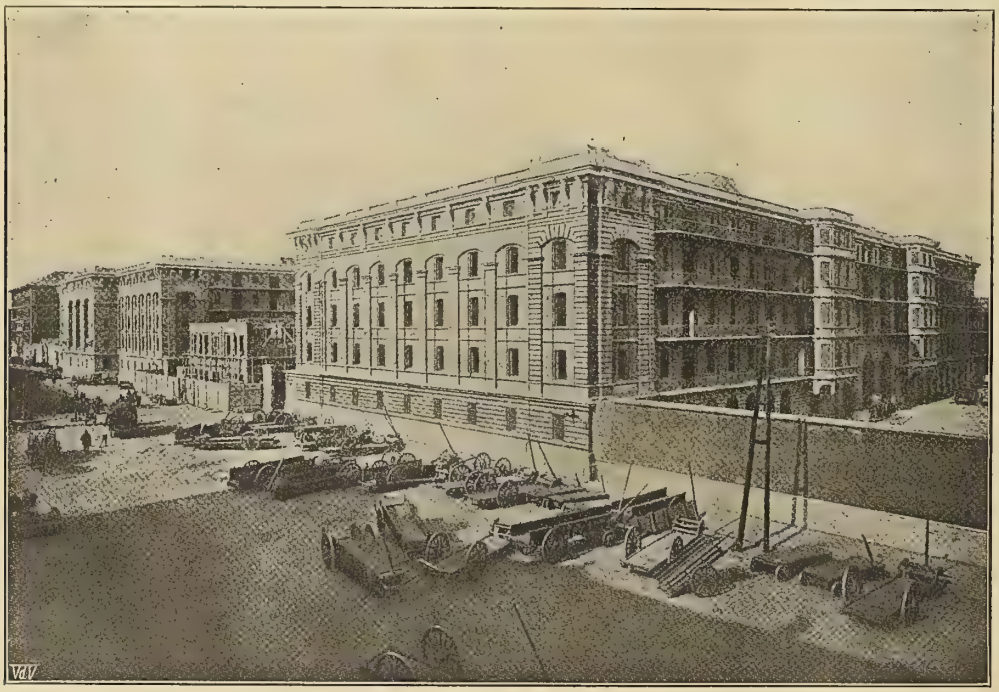
BY MC L. HARDING.*

Terminal engineering, especially that branch which pertains to the installation and operation of freight-handling machinery, has now become a most important branch of engineering. It is history that two cities may start with equally natural advantages but the one which furnished the best terminals and approaches will soon outstrip the other. There are many examples that the city which neglects its terminals endangers its commercial existence. A port may be said to be built up through convenient, quick and low-cost transference of freight between vessel and shore. A difference of one penny per ton in freight transportation will often change the destination of a ship's cargo.

Antwerp, one of the four greatest ports in the world in reference to foreign commerce, realizing this, is now making most extensive improvements and planning for a still greater enlargement of its commodious harbor. The city is located on the river Scheldt, about 53 miles from the North Sea. Antwerp forms the port of entry and exit for the trade of Belgium, and a portion of Southern Germany, of France and Switzerland. In order that there may be no limitations as to the length and depth of the vessels which here are to be accommodated, the Belgium government is arranging to cut an entirely new bed for the river and diverting its course. In general, there are two ways of increasing port facilities so as to give the greatest lineal frontage for the berthing of vessels. Where there is plenty of water area, as in a bay or harbor, the piers should be extended either at right angles or diagonally to the shore line. Another method is to build the quays parallel to the shore front and also to cut into the shore and form docks or basins. Antwerp, located upon a river, has built massive masonry and wide quays in length about 3 miles, and has constructed a number of docks or basins in addition. There are at present ten inner docks in the north of the city, three barge docks on the south, and an outlet to the Campine Canal for the use of inland shipping. There are six drydocks, 4,500,000 square feet of sheds and many large buildings, such as warehouses and storehouses.

Freight Transshipping. — Among the freight-handling machinery may be mentioned one sheer of 120 tons, two 40-ton cranes, one 50-ton crane, one 10-ton crane, one 5-ton crane and nearly 400 power cranes of smaller capacity. An apparatus for lifting and dumping trucks containing 25 tons of coal, a barge with movable appliances for the transshipment of ore and sixty powerful capstans were installed.

Transference of Freight Between Vessels and Cars.—



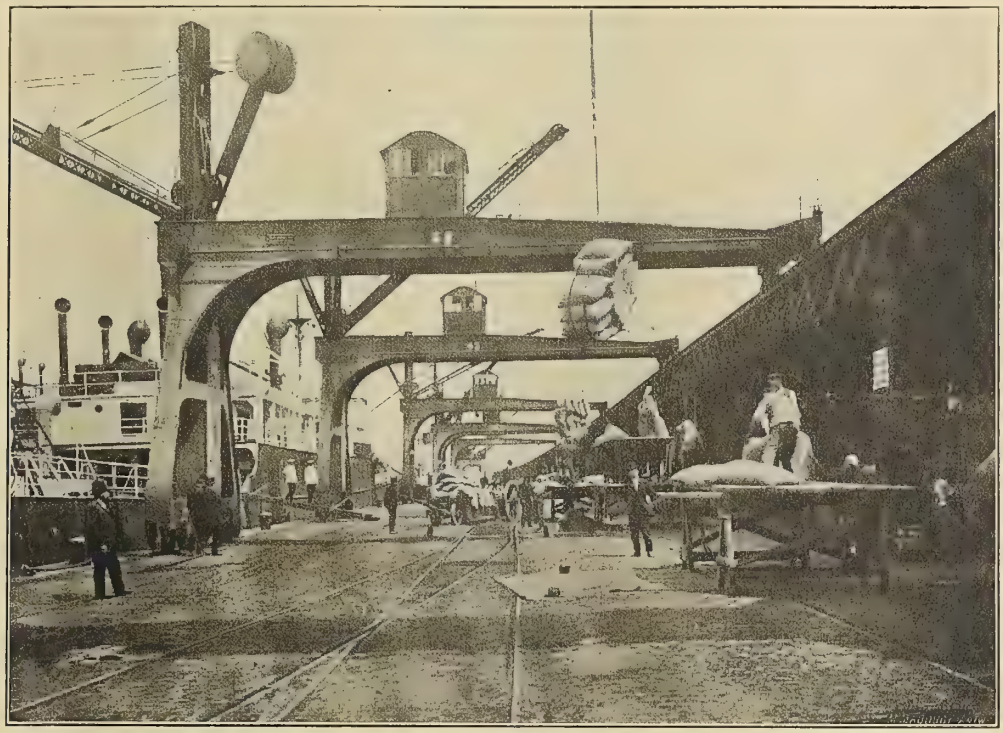
GOVERNMENT WAREHOUSES AT ANTWERP.

For this movement of freight there are ninety-one power cranes of 1½ tons and 2 tons capacity. These cranes are similar and move on a 4-meter gage line, allowing the cars to pass between the arches of the cranes. The cars are transferred from one track to another by sliding transfer platforms. By an agreement between the general government of Belgium and the town of Antwerp the latter supplies the power for the capstans placed along the quays, also for moving the transfer platforms and the railway trucks along the quay frontage. Many of the cranes have been installed for a number of years and should not be considered as representing the best practice. There are other quays and docks located a distance from the city to avoid the danger of fires, where petroleum, benzine and other heavy oils are loaded and discharged. The installation for this oil handling covers 74 acres. The main system of inner docks is at the north end of the city and covers 220 acres, and there is 46,200 running feet of quays and wharves. There are 262 acres on the quays for storing merchandise, where docks can accommodate about 350 vessels of moderate tonnage. At right angles to these two docks and parallel with the river bank is the Kattendyk Basin, which is in the center of the port

* Terminal Engineer, 20 Broad street, New York.

section of the city, and about it are grouped warehouses of large dimensions. There are six drydocks, as mentioned above, and the length of the new drydock, which has been commenced, will be 726 feet. Although Antwerp has the above facilities, yet for some time it has become apparent that the commerce of Antwerp must soon outgrow its docking accommodations.

About ten years ago engineers were put to work to prepare plans that would make the port equal to any demands that are likely to be made on it for many years to come. These plans have received the sanction of the royal government, and will make the port of Antwerp a larger one than any in existence,



HALF-ARCH CRANES FOR HANDLING FREIGHT ON ANTWERP PIERS.

and three times its present size. The new docks will consist of a canal in the shape of a quarter circle, 815 feet wide and nearly 40 feet deep, extending from the Kattendyk dock for a distance of about 5 miles to the northwest, and there entering the river Scheldt. With this canal will be connected a large turning basin, a system of drydocks for loading and unloading, each 660 feet wide with an average length of 3,960 feet, and complete handling equipment of the latest and most improved character. In the cutting of an entirely new bed for the river there will be removed several bad curves.

Antwerp up to date has spent more than $45,000,000 (£9,000,000) in improving her harbor, and the improvements above outlined are estimated to cost more than $55,000,000 (£11,000,000) in addition, making a total cost of about $100,000,000 (£20,000,000). It is the chief commercial city of Belgium, and has a population of above 300,000. All matters pertaining to the harbor and port are administered by the city.

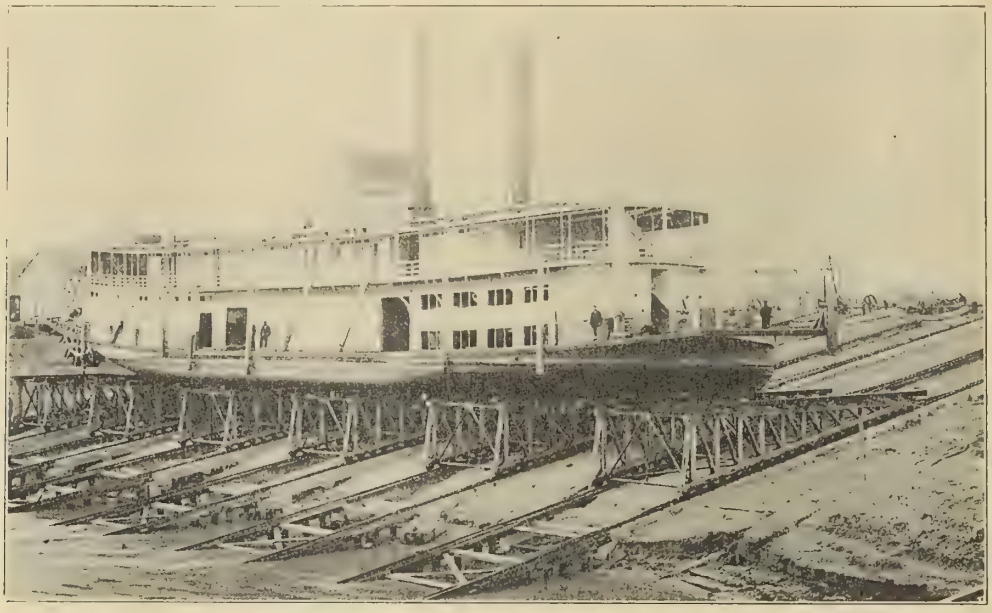
Sea-going vessels pay 10 cents (5 pence) per ton for two months and 1 cent per ton per month afterwards. Warehouses are rented by the month for 2 cents (1 penny) per square foot on ground floor and four-tenths of this amount per square foot on top floor. In 1907 by sea-going boats there were 11,200,000 tons. There is a charge of 10 cents (5 pence) per month per linear meter (3.28 feet) to merchants outside of the city; 14 cents (7 pence) per month per square meter (10/75 feet), and one-third of this amount for storage in yards. Cranes, 10 tons capacity, 39 cents (20 pence) per hour. Small cranes, 3,350 pounds capacity, 19 cents (10 pence) per hour.

The crane shown in the illustration deserves special study, both from its massive construction and the way it is supported, there being only one leg, the other end being supported upon the girder at the edge of the shed. There are many of these cranes. It will be noticed that the freight is transferred from the hold of the steamship either directly upon drays, cars or elevated platforms. These cranes are adjustable, so that they can be placed directly opposite the hatchways of vessels. For moving the freight between the vessels and the shore this crane does excellent work, but is limited to an in-reach of about 40 feet. If the freight is to be taken into the sheds there is the necessity of rehandling, and much of the advantage of the crane is lost. The freight, when loaded into the steamship, is generally stowed in the vessel without regard to consignments. It may, therefore, happen that the freight taken from the hatch may not be routed for a car directly opposite the hatchway, but for one of the train of cars located at a considerable distance to right or left of the car opposite the hatchway. This means rehandling by manual labor, which is expensive, and even more expensive than the rest of the movements. In similar cases elsewhere where the expense was 6 cents (3 pence) per ton to place on the pier to handle in and place upon cars within the shed, there was an additional cost of 26 cents (1 shilling). Other types of crane along the river and on the Campine Lock have two legs instead of one. These cranes are elevated so that cars and locomotives can pass beneath. There are open sheds back of the river quays for the temporary storing of freight, and elsewhere convenient to the water front are great government warehouses for storage purposes. These warehouses are of very pleasing architecture and fitted with all freight-handling appliances.

A replica of the first steamboat to navigate the Ohio and Mississippi Rivers has been constructed to aid in commemorating the centenary of steam navigation on the inland waters of the United States by steaming from Pittsburg to New Orleans.

SIDE-HAUL RAILWAY DRY-DOCK FOR THE UNITED STATES GOVERNMENT.

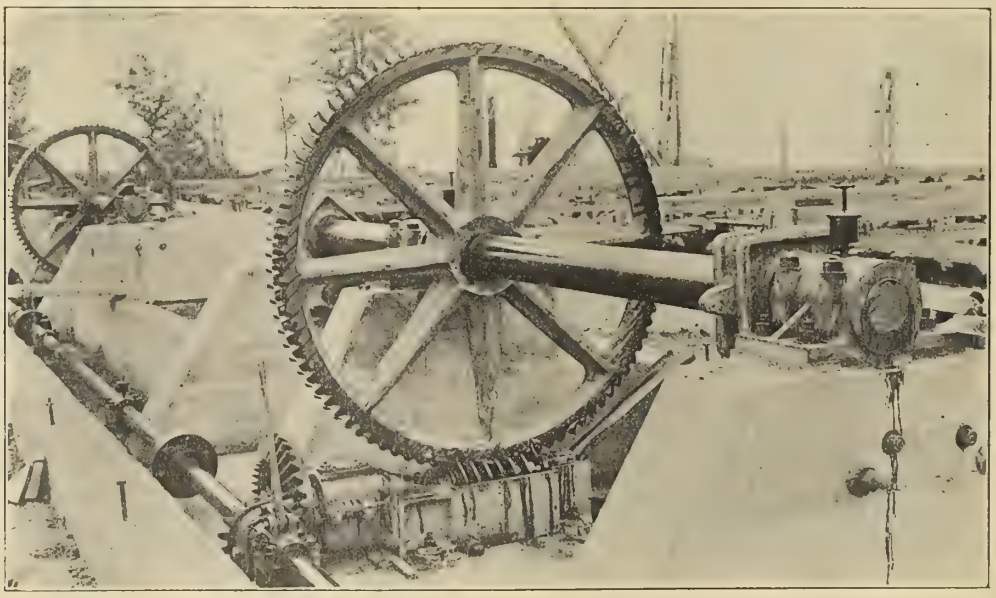
Some months ago there was completed for the Mississippi River Commission a side-haul railway drydock of 1,500 tons capacity, which contains some unusual features, and which in all probability represents the most highly developed form of this kind of drydock. The question of the type of drydock which would meet the requirements to the best advantage was carefully considered, with the result that the side-haul was chosen in preference to the end-haul or the floating dock, as better adapted for the handling of the flat-bottom, shallow draft boats predominant on the Mississippi River.



NEW 1,500-TON, SIDE-HAUL RAILWAY DRY-DOCK ON THE MISSISSIPPI RIVER.

The site selected for building is at West Memphis, Ark., which is the headquarters of the Mississippi River Commission's fleet of dredges, steamboats and other floating craft, and where the repair shops are located. To prepare this site for the foundations, and to bring it to grade, some 13,000 cubic yards of earth were removed from the bank, the deepest part of the cut being about 19 feet. The material was dug and handled by heavy scoops of one cubic yard capacity, which were operated by engine power. A small amount of dredging for the underwater portion was also required.

The dock in general consists of twelve lines of tracks, laid in pairs, of total length 315 feet. The upper portion of 150 feet is composed of reinforced concrete, connected to the lower portion of 165 feet, which is built of timber and thoroughly braced. The upper portion rests on reinforced concrete piles, spaced 7 feet 6 inches centers, while the lower is secured to timber piles. The distance between each pair of tracks is 19 feet, while the individual pairs measure 15 feet



WORM-GEAR MECHANISM USED IN OPERATING THE SIDE-HAUL DRY-DOCK.

centers; the total width from outside to outside being 185 feet. The grade is 1:6. Upon the tracks travel six fabricated steel cradles, which measure 52 feet long horizontally. To the under chord are attached the truck wheels, which are of cast iron, double flanged, chilled tread, 12 inches diameter,

and run in enclosed bearings, which contain grease reservoirs. On the top chord is placed a patented device for releasing the cradles from under the bottom of the vessel, and which is operated by releasing and tripping mechanisms, handled from the outside of the cradles. By this means the cradles can be conveniently and quickly released, leaving the vessel, if so desired, resting upon blocking laid upon the ground in the 19-foot space between the cradles and independent of them. Any extensive repairs may, therefore, be done on the vessel, while the drydock may be used for further docking.

The cradles are hauled on the endless chain system, the chains passing over sprocket-wheels, which are operated through worm-gear mechanisms. These are of the special M. R. side-welded, long-link type, and of the highest quality of material and workmanship.

The hoisting machinery consists of six separate units, which are operated by a line shaft extending from one end of the foundation to the other, and which is made to revolve by double-cylinder reversing engine placed in mid position. Each unit may be operated independently of the other, or the whole lot may be run in unison by simply throwing in or out the shifting clutches. The foundations are composed of concrete, bedded solidly in the ground, and braced to the heads of the tracks. The time of hauling full-rated load the total length of the track is 45 minutes.

This dock was built by the well-known firm of drydock builders, H. I. Crandall & Son Co., of East Boston, Mass. The chains were manufactured by Bradlee & Co., of Philadelphia, Pa.

Mr. Oscar R. Cauchois, assistant general agent of the Compagnie Générale Transatlantique at New York, has been decorated Chevalier de la Legion d'Honneur, in recognition of his many years of valuable service in promoting and furthering commercial relations between France and the United States.

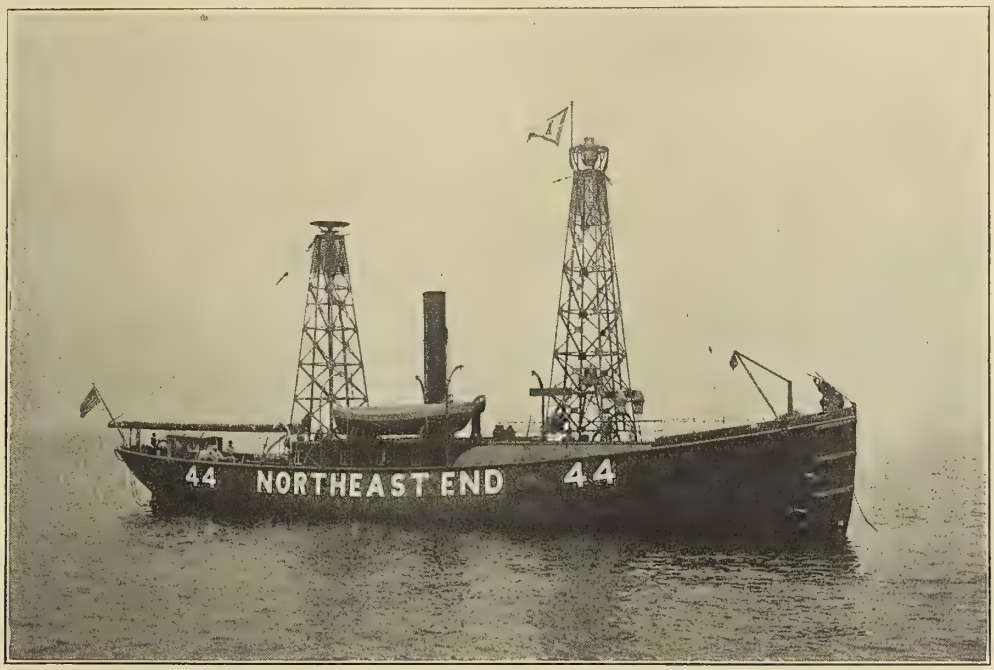
Mr. Omar N. Steele, manager of the Cleveland yards of the American Shipbuilding Company, died Aug. 17, aged 68 years. He was an engineer on the Great Lakes for twenty years, and brought out the first iron boat built on the Lakes.

PROGRESS OF DISSOLVED ACETYLENE FOR MARINE SIGNALS.

The adoption of acetylene for lighted aids to navigation dates back less than one decade. Beginning with the cumbersome carbide generator beacon (such as are still in use to-day in Mobile Bay), the acetylene aid has developed through the various types of apparatus which generate their own gas on the light stations up to the modern and scientific system where the illuminant is compressed into portable steel cylinders charged at large generating plants on shore. The process of safely storing large quantities of gas in small cylinders suitable for marine work is known as the "acetone process," and is a European invention. Pure acetylene alone cannot explode, but when combined with air in certain proportions it becomes highly explosive, therefore it is dangerous to compress neat acetylene in store holders; but with the acetone system the gas can be highly compressed with just as great safety as you would compress ordinary air.

Acetone is a liquid somewhat resembling alcohol, and has the property of absorbing or dissolving twenty-five times its own volume of acetylene per atmosphere of pressure. Before introducing the acetylene, the cylinders or accumulators (which are of heavy solid drawn steel) are filled with a porous mass composed of infusorial earth, charcoal, asbestos and certain metal oxides. This mixture is poured into the cylinders as a semi-liquid and, after being carefully shaken down, so that every space is completely filled, allowed to harden. This hardening process is assisted by baking in a special oven. In this mass, which is 80 percent porous, there is no space large enough for an explosion to occur, and in no case can an explosive wave travel through the porous mass. An amount of acetone equivalent to 40 percent of the internal volume of the cylinder is next poured in, and the cylinder is then ready to receive the acetylene. The initial supply of acetone is sufficient (with very little replenishing) to last for the complete lifetime of the cylinder. A cylinder prepared in this manner will contain 100 times its own volume of acetylene at ten atmospheres pressure (150 pounds per square inch).

No surer guarantee of the absolute safety of dissolved acetylene prepared in this manner exists than its present



NORTHEAST END LIGHTSHIP NO. 44, OFF CAPE ANN, EQUIPPED WITH ACETYLENE FLASHING LIGHT.

extensive employment by the Light House Bureau of the United States Department of Commerce and Labor for lightships, beacons and buoys.

Accumulators are made in various sizes to suit all varieties of lighthouse work. The large cylinders are used in connection with buoys, one of these containing sufficient to maintain a buoy in operation for from one to two years. The type usually employed for beacons and light vessels weighs, when fully charged, about 200 pounds, and contains at ten atmospheres pressure 180 cubic feet of available gas.

The next most important part of this lighting system is the mechanism for reducing the pressure of the gas to suit the burner and for producing distinctive light characteristics, *i. e.*, alternate light and dark intervals. The flashing mechanism is provided with accessible adjusting screws by which it is possible to adjust it accurately to any desired characteristic.

Occulting light as a peculiarly distinctive signal is well known to mariners. The pilot burners used with this system consume about 1/75 of a cubic foot of gas an hour, which is about one-third of a cubic foot of gas a day.

The powerful light produced by acetylene, together with the wide possibilities provided by this flasher in producing any desired light characteristic, has introduced to lighthouse work an opportunity for improving all minor lights. Hitherto only relatively large light periods (five seconds or more) in combination with dark intervals of about the same length have been used; partly owing to the adherent limitations in the design and structure of the flashing mechanism, but chiefly on account of the feeble lighting power of the illuminants used. In large lighthouses short flashes have been in use for years, and are considered by all lighthouse experts more effective than long flashes. The characteristic most used with this new system is .3 second followed by 2.7 seconds eclipse. With the multiple flashers used with this system a great variety of light characters are readily obtained such as hitherto have been possible only in large lighthouses provided with revolving lenses or screens operated by machinery.

Another interesting feature of this system is the device known as the sun valve, which automatically performs the functions of a light keeper. The sun valve is a combination of metal rods which, by the action of light, control the flow of gas to the burner, closing off the gas in the morning and thus extinguishing the light, and opening the chamber for the gas to flow again at night when the light is again required. Fifty percent of the gas supply is saved by this mechanism. The sun valve will operate equally well in cold or tropical climates.

Last summer Cornfield light vessel, Long Island Sound, was equipped with an acetylene flashing light. This is the first lightship in which an acetylene flashing light apparatus has been installed in America. This year light vessel No. 44, off Cape May, was similarly equipped. Four other light vessels are being fitted out at present, and will be installed at important light stations on the Atlantic coast.

The accumulators, six of which are generally employed, are installed below the main deck; the piping is carried from the accumulator through a manifold to the pressure regulator, which is fastened underneath the deck, thence to a valve also underneath the deck, and then up the mast to the lantern.

The pilot light operates continuously, but the main light is cut off in the morning by the valve just mentioned and allowed to light up again when required at night. The lantern containing the flasher is suspended on gimbels at the masthead, so that in the heaviest sea it remains perfectly vertical, and thus throws the light beams in a horizontal plane at all times. These acetylene lights are visible at 15 miles in clear weather. This system is replacing the old oil lamps, and eventually will be used on all light vessels, with the exception of those using very powerful electric arc lights.

The dissolved acetylene light system is now in use all over the world. In America the following important channels and light stations have been equipped: Ambrose Channel, in which eight buoys are now employed; Point Judith, Montauk Point, and various minor light stations along Long Island Sound; Great Round Shoal (near Nantucket Shoal), also off Atlantic City, Fenwick Island Shoal, Winter Quarter Shoal, Hetzel Shoal, Tampa Bay, Savannah harbor, Charleston harbor, etc.

Acetylene beacons are installed in Alaska (thirty or more); also off the coast of Oregon, Washington and Maine, and forty or more from Maine to Florida. They are also used in the Hawaiian Islands, on the Great Lakes, and the Livingstone Channel in the Detroit river will be lighted throughout with beacons and buoys using dissolved acetylene.

Contracts for U. S. Torpedo Boat Destroyers 43 to 50.

Bids were opened at the Navy Department, Washington, on Aug. 7, 1911, for the construction of eight torpedo boat destroyers. The award of contracts was made on Aug. 27 to the following successful bidders, at price of construction and under guarantees as given below:

ACCEPTED BIDS FOR UNITED STATES TORPEDO BOAT DESTROYERS NOS. 43-50.

		Bath Iron Works.	New York Shipbuilding Co.	Fore River Shipbuilding Co.	Cramps Shipbuilding Co.
A	Number of vessels	2	1	1	4
B	Price of construction, each vessel	$761,500 (£156,000)	$781,500 (£160,000)	$779,450 (£164,000)	From $761,000 (£156,000) to $766,500 (£157,000)
C	Time to complete, months	24	24	24	Ranging from 22½ to 24
D	Speed in knots	29	29	29	29½
F	Maximum consumption of fuel oil per knot run at 29 knots	710 lbs.	700 lbs.	686 lbs.	705 lbs.
G	Maximum consumption of fuel oil per knot run at 12 knots	175 lbs.	175 lbs.	110 lbs.	170 lbs.
H	Mean trial displacement	1,010 tons	1,073 tons	1,010 tons	1,046 tons
K	Length of vessel	300 feet	300 feet	300 feet	300 feet
L	Shaft horsepower	16,000	15,900	15,350	16,500
M	Type of machinery	Parsons turbines, 3 shafts with 1 reciprocating engine on each wing shaft.	Curtis turbines, 2 shafts with 1 reciprocating engine on each shaft for cruising purposes.	Curtis turbines, 2 shafts with 1 reciprocating engine on each shaft for cruising purposes.	Cramp-Zoelly turbines, 2 shafts with 1 reciprocating engine on each shaft for cruising purposes.
N	Type of boilers	Normand	Thornycroft	Yarrow	Express

From the price of construction given for New York S. B. Co. and The William Cramp & Sons S. & E. B. Co. $4,000 and $4,900 may be deducted respectively if vessels are tried on Delaware Breakwater course.

Monthly Shipbuilding Returns.

The Bureau of Navigation reports 115 sail and steam vessels of 17,499 gross tons were built in the United States and officially numbered during the month of August, 1911. Two steel steam vessels of 4,897 gross tons were built on the Atlantic coast and two steel steamships of 7,372 gross tons were built on the Great Lakes.

THE LOCATION AND DISPOSAL OF DERELICTS.

BY STANLEY V. PARKER.

Derelicts always have had a fascination for those who are interested in the sea and its mysteries, but a practical consideration of them has seldom appealed to other than those whose profession made them aware of their danger and interest. A few years after the meeting of the International Marine Conference at Washington, which came to the conclusion that a division of the sea among the nations of the world for the purpose of keeping the pathways of commerce clear of dangers was impracticable, the activity of the United States hydrographic office in the interest of shipping resulted in the publication of a paper of statistics about derelicts. As a result of this, the British maritime interests took up the question of the removal of derelicts under the impression that the British government had never taken any steps in the matter. A board, consisting of members from the Board of Trade and the Admiralty, after a careful and exhaustive taking of testimony, placed as they were on the defensive by the demands of the maritime interests, concluded that as the number of derelicts afloat was so small and the *known* collisions with them so few, no action in the matter further than had already been taken by those responsible for the removal of wrecks in British home waters was justified. However, the United States government, being more afflicted with these menaces of the ocean, employed the vessels of the United States navy at times for their location and removal and, finally, Congress authorized the construction of the derelict destroyer *Seneca,* the first vessel built for this express purpose.

Except those whose duties connect them with the location and removal of derelicts, few mariners realize the difficulties that beset the path of those engaged in the work. It is no rash statement that the location without some method is as difficult as the proverbial attempt to find a needle in a hay stack. However, methods have been developed for this work that have proved successful and others are hoped to prove successful, and it is with some of these and of the methods of disposal that this paper will deal.

CRUISING SUSPECTED AREAS.

The methods of cruising to cover a given area in which a derelict is suspected to be are several. In one, a series of concentric squares or rectangles is cruised about the origin,

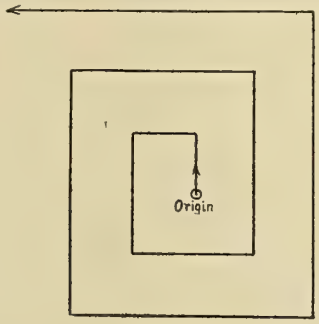


FIG. 1.

the last reported position of the derelict, as a center (Fig. 1). This does not appear to be a very satisfactory method, for, if we have any information in regard to winds and currents that have prevailed, we are simply wasting time on a great part of the area. This would seem to be equally true of the method in which a spiral is cruised about the origin. The more we can restrict our cruising area, the less the distance we have to cover and the longer our coal will last. Both of the methods just mentioned may be used to good purpose in searching for stranded wrecks whose position is uncertainly located, but their use would seem to be a waste of time in locating drifting objects when we can forecast at all the direction of drift of the derelict.

Another method consists in cruising a series of partial rectangles along a line which we assume lies in the direction that the derelict has drifted (Fig. 2). This should prove to be a very efficient method, provided we have an efficient scheme for estimating the derelict's drift. As the uncertainty of the derelict's direction of drift varies as the square of its distance

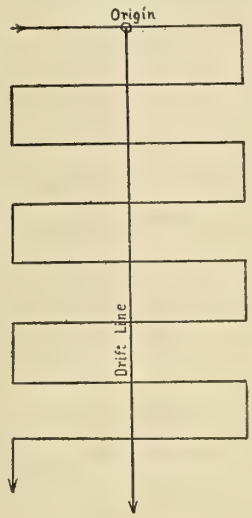


FIG. 2.

from the origin, it would seem to be wise to lengthen the rectangles laterally as we recede from the origin. This constitutes another method of covering cruising ground. If we can estimate the proper length of the sides of these rectangles at a certain distance from the origin, we can thereby determine a sector to which we can confine our cruising. The angular magnitude of these sectors will depend on the exactness of our knowledge of the winds and currents that have prevailed. To cover a linear distance of 100 miles along the bisector of a

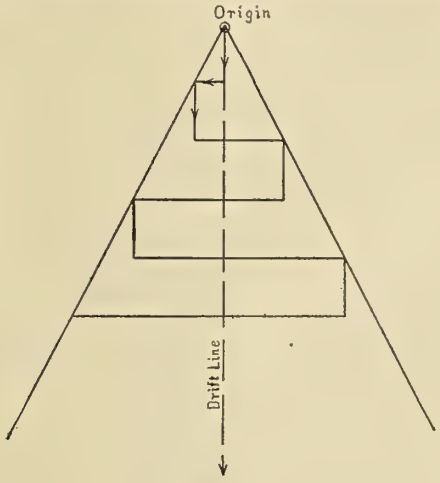


FIG. 3.

90-degree sector would require us to cruise a distance of about 640 nautical miles. This would require, supposing we confined our cruising to daylight, cruising for 12 hours a day at ten knots, about five days, and it would seem to give a very discouraging outlook. But we must notice that, although we may not be drifting at the same rate as the derelict, nevertheless we are generally drifting in the same direction and the derelict is not drifting away from us as fast as at first glance might appear. We will consider this in more detail later.

In the case of a 45-degree sector (Fig. 3) we will have to cruise a distance of 290 for every 100 miles along the bisector.

This would require a little over two days' cruising at the speed above mentioned. In all the diagrams illustrating the sector method, the lines for cruising over are at a distance apart equal to twice the range of vision at a height of 60 feet, and it was on the assumption that the crow's nest would be at this height that the distance and times above noted were computed. This height of 60 feet was assumed because if we work with a less height, our distances to be cruised are greatly increased, and a height of 60 feet can be attained on almost any seagoing vessel. It will also be noted that we cruise directly along the bisector until the sides of the sector separate a distance equal to twice the range of vision, and that then the method of cruising becomes that of the varying rectangle. In many cases it will be necessary to lessen the distances between cruising tracks on account of the thick weather, etc., or the search may have to be, for the time being, discontinued, but it is not advisable to reduce them if we can see distinctly.

DETERMINING THE DERELICT'S DRIFT.

In considering the time elapsing between the sighting of a derelict and the arrival of the destroyer at the point at which the search is to begin, it will be of value to consider their general location in the North Atlantic. Issuing from the Gulf of Mexico through the straits of Florida, the gulf stream flows to the northward along the coast, tending always more to the eastward. South of Nova Scotia its course is almost due east, but after clearing Cape Race its course is more to the northeastward. It is not always well defined, being influenced by the winds, but its maximum and minimum rates of drift are fairly well known in most positions. Abandoned vessels along our coast are, in the majority of cases, found in this stream and, carried along in it, they sometimes cruise thousands of miles. In any part of the stream they are a menace, but in that part of it south of Newfoundland they are directly in the path of the fast transatlantic liners They are at times found in the counter and branch currents of the gulf stream, such as the Arctic current that rounds Cape Race, in the counter current along our coast, or in the branch current flowing from a position approximately latitude 41 degrees, longitude 50 degrees to the southeastward and southward to the great calm belt in the middle of the ocean, commonly called the Sargasso Sea. An examination of a current chart of the North Atlantic Ocean would seem to indicate that under certain circumstances a derelict vessel might make a complete circuit of the ocean, and that this is possible is shown by the cruise of the derelict schooner *Fannie E. Wolston.* Abandoned off Cape Hatteras, Dec. 15, 1891, she was carried very nearly due east, was drifted about in the calm belt, reaching a position as far east as longitude 38 degrees 30 minutes or about 1,770 miles east of Hatteras, was then carried to the southward, thence to the westward and on Feb. 29, 1894, was seen about 240 miles S. S. E. of Cape Hatteras. She had then been a derelict 850 days and had cruised 7,025 miles.

The information concerning derelicts in the North Atlantic Ocean is ordinarily transmitted to the United States hydrographic office and is published in its bulletins and represented graphically on its pilot charts. The New York *Herald* also publishes daily such similar information as may be reported to it. Generally it is not submitted until the reporting vessel's arrival in port, and this, from the general position of derelicts, results in a delay of the report of from perhaps 24 to 72 hours. Add to this the time it takes the destroyer to reach the point for commencing the search, say 18 to 60 hours, and the arrival at the point is delayed some 42 to 132 hours. This might be avoided if the masters of reporting vessels equipped with wireless would send in report at the time of sighting the obstruction. Between the time of the sighting of the derelict and the arrival of the destroyer, the derelict has had an opportunity to drift, and, as their rate of drift may be as great as 2½ knots, in fact derelicts have been known to drift that fast, her position may be at a distance of some 300 miles from the origin. An accurate estimate of the vessel's drift would be difficult to make, given our present knowledge of the subject, and some method of approximation is all that we can now hope to use.

The consideration of the relative effect of wind and current on the derelict's drift is of considerable interest. It will be found that where a current of any strength prevails, the ultimate position of the derelict depends upon the current. This is particularly true of the gulf stream. However, the position within the current or the predilection of the derelict for branches of it will depend upon the wind. Thus, as the current may be hundreds of miles in width, the derelict's position within the current is of as much importance to us as its ultimate destination, if it is not more important. The reason for the great difference in the effect of these two elements is that the current is practically always in motion, while the wind may be light or there may be calms at times. Again, the tophamper of a vessel is oftentimes carried away after a time, and the wind has little surface exposed to it. In the horse latitudes the jumble of tracks of a single derelict shows the uncertainty of purpose due to the absence of current and the prevalence of variable winds or calms. This uncertainty is seldom seen in the tracks of derelicts in the gulf stream. The effect of wind as determining the derelict's predilection for a part of the current or for branches of it, is well shown in the tracks of the two derelict vessels, the *Anna R. Bishop* and the *Elvira Ball.* Both abandoned on the American side of the Atlantic; they both passed very close to the point in the stream above mentioned where the branch of the current flowing to the southeastward branches off. The *Bishop*, evidently meeting southerly winds at this point, was driven to the northward into the branch flowing toward Greenland, then met northerly and westerly winds and was driven toward the British Isles. The *Ball,* meeting northerly winds at the point above mentioned, was taken in charge by the southeasterly branch, then encountered westerly winds after arriving in the area of little current, and was finally picked up not far from Fayal in the Azores. The final positions of these vessels were hundreds of miles apart.

A very few derelicts have drifted counter to the gulf stream, but they are but a few out of hundreds; and if such a one was sighted more than once, the reported positions would be a guide to that fact.

A vessel's speed before the wind would depend on the ratio of the areas exposed to the wind and exposed to the water resistance respectively, and we have no accurate information as to their behavior under the various circumstances. A method of determining a derelict's position when acted upon by the wind alone, which has suggested itself, might be of considerable value, as the knowledge of the actual rate of drift does not enter. We assume that the speed of the derelict varies directly as velocity of the wind. Suppose we assume that a wind of Beaufort scale force 5, having a velocity of 24.3 nautical miles per hour, causes a drift of one nautical mile per hour. Then the drift that any other wind will cause will be proportional to its velocity with respect to 24.3. We can now prepare a table giving the ratios of the various winds of the Beaufort scale to the standard breeze No. 5. Suppose we have a record of the wind's force and direction since the sighting of the derelict. We multiply the number of hours' duration of the first wind by its force multiplier in the table and lay down in nautical miles from the origin the resulting number in the direction in which the wind has blown. Now proceeding with the next wind that has blown as before, lay down its length from the last point reached. So continue until we have completed the plotting up to the time of

TABLE OF MULTIPLIERS.

Beaufort No.	Velocity.	Multiplier.
1	6.9	.284
2	11.3	.465
3	15.6	.642
4	20.0	.823
5	24.3	1.000
6	29.5	1.214
7	34.7	1.428
8	41.6	1.712
9	48.6	2.000
10	56.4	2.321
11	65.1	2.679
12	78.1	3.214

[Note:—It will be noticed by reference to the Beaufort scale that the values of the velocities in the above table are, with the exception of the No. 12 wind, the maximum values. It would seem to be advisable to use instead the mean values, but inasmuch as we are simply using the values of the velocity to obtain *ratios,* it is not essential that we use the mean values, as the proportions would be practically the same.]

arrival of the destroyer at the point of commencement of the search. Now let us assume that a 5 breeze causes a drift of two knots. Our values in the table will be doubled and, plotting the tracks again, using the same data as before, but using the new table values, we reach another point which, it will be discovered, is on the extension of the line drawn from the origin through the first point reached. It is probable that, no matter what assumption we make as to the actual rate of drift, provided we assume that the drift is proportional to the velocity of the wind, all the points reached will be on this line. And that this is true is easy of demonstration. The determination of this line, then, simply requires the determination of one final point as above, and our line will be that joining the origin with it. We can not determine the exact position of the derelict along this line, but we now have some means of restricting our cruising area.

The average quartermaster can judge the Beaufort force of the wind to at least the first scale number on each side of the actual force. This would mean, in the case of a five breeze, an error of about five knots, or proportionally of about one-fifth. It is evident that if the errors are all plus or if they are all minus, no error will result in the direction of the line, but that if the estimates are one-half plus in error and one-half minus in error the error in the trend of the line will be a maximum, for in the first case the quartermaster has practically used a table with larger or smaller multipliers, while in the other case the error is always onesided. The errors will effect a maximum error in the trend of the line when the track lines are nearly perpendicular to the locus obtained, and will be a minimum when the lines nearly parallel the locus, being in intermediate positions proportional to the sine of the angle of the tracks of the locus. The practical application of this point (Fig. 4) would consist in laying off on each side of the locus at the final point a distance perpendicular to the locus equal to one-fifth of the total departures, as the projection of the various tracks on a line perpendicular to the locus might be called, thus forming a sector. This would result, in case of tracks near the origin which were generally perpendicular to the locus, in the sector formed by the lines from the origin to the two correction points being of great angular extent. Practical considerations of distances to be cruised would generally limit the sector to 90 degrees, as it is simply a provision against error that may or may not exist.

It is evident that to correct our line of current it will be necessary to shift it in the direction of the set a distance equal to the drift per hour times the number of hours since the last report of the derelict. This, of course, refers to a current constant in drift during that time. If the current is not constant the line becomes a curve, difficult of determination. These observations are true, because no matter what the position of the derelict along our locus, provided the current is constant, it will be set an equal distance in an equal length of time. On the other hand, not knowing the exact position of the derelict on the locus, if there are different currents along it, we can not determine when it entered a particular current, nor how long it remained in that current, so that the shift of the locus becomes variable, according to the length of time spent in each part.

The question now occurs: "How are we to obtain the drift of a current at sea so as to correct our line for current?" An examination of a current chart of the North Atlantic (hydrographic office No. 1,308) will show that the currents with their drift per day (24 hours) are noted on the chart. It will also be noticed that in most cases two values of the drift are given. This means that under certain circumstances at certain parts of the year the drift is greater or less than at others, although during a period of several days or weeks it may remain the same. This fact, then, adds a complication to the shifting of the locus for current, and it will be necessary to apply both drifts unless we have more accurate information. So that to shift our line we will run it up according to both values of the current given, thus obtaining two lines parallel to each other, so that the probable position of the derelict is somewhere between them (Fig. 5). These lines will be, of course, at a distance apart equal to the product of the days and the difference between the two rates of drift. In the stream to the eastward of Cape Henry the two values appearing on the chart are 24 and 95, about the greatest difference in drift that we find. Supposing five days to have elapsed since the sighting of the derelict, the lines will be 355 nautical miles apart. If we were to use these lines as the sides of a parallelogram approaching a rectangle, the other sides being 100 miles apart, for defining a probable area, it would be necessary to cruise an area of 35,500 square miles in the search. This, if we used the rectangular method of cruising, would necessitate the cruising of a distance of 2,000 nautical miles, which, at the rate of cruising noted above, would require about 14 days. A greater number of days between the sighting of the derelict and the arrival of the destroyer at the point of search, in this part of the ocean, would require a correspondingly greater time of cruising. We see from this the need of the utmost speed in reaching the area to be searched.

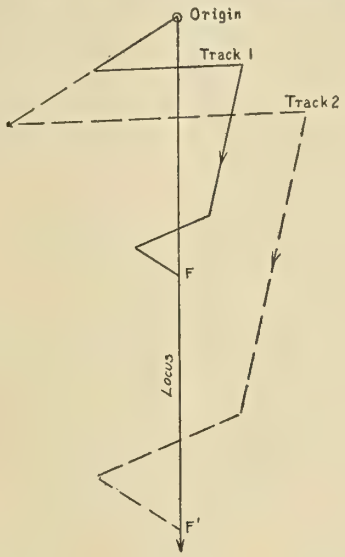


FIG. 4.

With a familiar knowledge of the effects of the seasons and weather on the gulf stream, derived from experience and what has been published on the subject, it may be possible to restrict the probable current values to still closer limits, and thereby reduce the area to be searched. Off Cape Hatteras, it will be noticed that a multiplicity of current sets and drifts prevail; it would be necessary in a case of this kind to apply the very maximum and minimum limits of the assortment of current sets and drifts if we cannot say accurately which current the derelict may be in. This would relieve us of the necessity of determining the curve for the variable set and drift of the current above mentioned, although it would undoubtedly increase the area to be covered. Sometimes the currents in a neighborhood will be so contrary in set and so variably in drift that we will have great difficulty in making any estimate at all. A guide as to which current the derelict is in might be

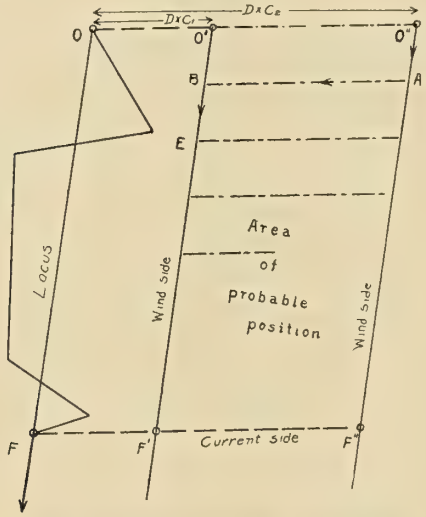


FIG. 5.—SHIFTING OF LOCUS FOR CURRENT.

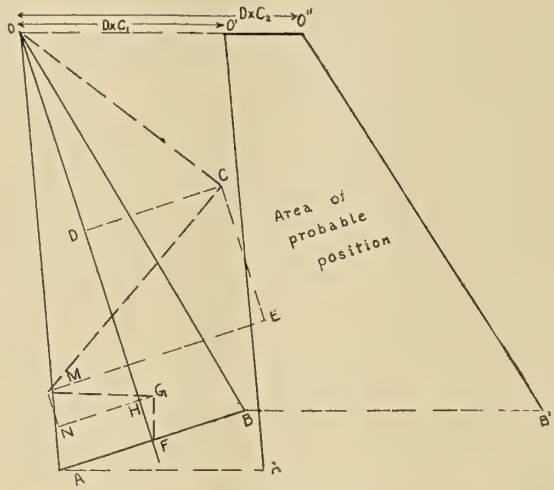


FIG. 6.—CORRECTED SECTOR, SHIFTED FOR CURRENT.

sure that the derelict's drift will be that which would be caused by the prevailing wind.

The locus should be corrected for wind and current up to the time of the arrival at the point selected for the commencement of the search. It will be remembered that with our locus method we obtained a line that the object of our search would be on if the wind alone had affected her; again, we saw that in order to correct this line for current it would be necessary to shift it. Using the maximum and minimum values of the drift, the line when shifted would be represented by two lines, one for each rate of drift and, evidently, to cruise the area between the lines will consume considerable time. If we can further restrict the area to be cruised we will be much better off. The use of tables with various drift assumptions for the standard breeze will be of value when we have had enough experience to be able to assume a fairly accurate drift of the derelict from her build, rig, etc., as obtained from Lloyd's Register and the description of her condition received from the vessel that sighted her. Having made that assumption we can then use the table that has that rate of drift for the standard breeze. However, until that is done, we must do the best we can with the present table.

the temperature of the water at the origin, but too implicit faith should not be placed in such a test, and it would at least require us to proceed to the origin. We see then that we have some method for determining the area to be searched, although this area may be considerable.

To show the application of these theories, let us suppose we are ordered to search for a reported derelict. The navigator should obtain from the vessel which reported it, if possible, an abstract of her weather log for a few days preceding and following the sighting of the derelict, together with the approximate positions at the times of the entries. He should also attain the position of the derelict anew, as an error of hundreds of miles might result from a telegraphic or typographical error. With this information and any other weather information of the position on hand, the wind locus should be determined and corrected for current approximately. When the vessel leaves port she should obtain from the lightship nearest the position of the derelict, and vessels in that neighborhood and which have been in that neighborhood, abstracts of their weather logs, and the locus should be corrected so as to represent that obtained from the most accurate information. The approximation of these winds obtained from the pilot charts, the use of which has been suggested, would be of little value unless no other information were available. The data on the pilot charts represent average conditions, and in places other than the trade belts a deviation from the average would very probably exist for days at a time. It is only necessary to glance at a pilot chart to see that a derelict will for days run counter to the longest wind lines. Neglecting current, they may follow these average winds in the long run, but as our search is limited to days or weeks, we can not be

Having shifted locus, origin and second point so that we now have two loci, two origins and two second points, we, by them, determine a parallelogram that represents in its area the area of the probable position of the derelict (Fig. 6). Upon reaching the minimum drift origin position (or the maximum if that be closer) the searching vessel would be put on a course along the current side until she reached the opposite wind side of the parallelogram, when her course would be changed to follow the far side until she had gone along that side a distance equal to twice the range of vision at the crow's nest, when she would parallel the first course back, continuing this as in the rectangular cruising method, although the partial figures may not be right figures. After we had finished cruising the parallelogram, if we had not found the object of our search, we should continue over an extension of it until we were compelled to return for coal. By so continuing this cruising we would nullify any effect of the error of the assumption that the drift before the wind was 1 to 0 for the standard breeze. If our wind locus had been corrected for possible error in judgment of the wind and, therefore, is a sector, our shifted figure would be an irregular one, resembling somewhat a trapezoid.

It will be noticed that the closer the knowledge of the current drift and the more nearly the maximum and minimum values approach each other the nearer our loci lines approach

each other, and the less the area to be searched, until, if the current is accurately known and has but one value, the locus will be shifted as one line or figure. In this case it would be advisable to make the locus the bisector of a cruising sector and follow the sector cruising method.

Each day we should continue the search until dusk, when cruising should be discontinued and the vessel simply kept under control until daylight, being kept near her position when she stopped searching by cruising in a restricted area, and at daybreak searching should be resumed. We can assume with accuracy that the destroyer is drifted by the current at the same rate as the derelict. The assumption that she has been drifted at the same rate as the derelict by the wind would not be accurate. This rate of drift depends, as was said before, upon the relative area submerged and exposed to the wind, and these will not be necessarily the same for any two vessels. But the difference would only be material with winds of considerable force. Therefore, under average conditions, it would be proper not to correct the position of the ship on the diagram as the result of sights taken, but we would consider that the destroyer, derelict and diagram had all been drifted an equal amount, and our dead reckoning would be used as far as our cruising for the derelict is considered. Of course, I do not mean to say that an accurate record of the ship's position should not be kept, but it would not be used to correct the ship's position on the diagram.

If on account of the great length of time spent on the search, the knowledge that the derelict is light and will therefore drift faster than the ship, or that she is waterlogged and will not drift so fast, during all of which time a considerable wind were blowing, there would be doubt of the advisability of acting as above noted. It would be better to use the ship's observed position and correct the diagram for the force and direction of wind and current that has prevailed since the beginning of the search, and then maneuver to get back to the diagram where we left it.

There is no doubt that the information given commanding officers ordered to search for derelicts is far from satisfactory. A sample report taken at random from the New York *Herald*:

> "Boston, March 21. Steamer *Nanna* (Nor), from Macoris, reports March 16, latitude 36—17, longitude 70—41, passed a vessel, bottom up, about 200 feet long, evidently a recent wreck."

Here we have no information whatever concerning the winds prevailing at the time, nor the apparent current experienced, and we must rely on information obtained subsequently either from the nearest lightship or from the pilot chart and current chart, or on the chance of getting some information from vessels that have been in that vicinity, and this information we may or may not be able to obtain. This is a typical report, and I have never seen one that really contained any valuable information from the standpoint of the searcher.

To remedy this I would suggest a form of report somewhat like the following:

REPORT OF DERELICT SIGHTED.*

1. Position — Latitude / or / Longitude — bearing / or / dist.
2. Date and hour of sighting.
3. When and where last seen (if as above, so state).
4. Name of derelict.
5. Rig.
6. Condition (Bottom up or otherwise).
7. Masts (Standing?)
8. Condition of hull (Breaking up? etc.).
9. Wind's force and direction at time.
10. Wind's force and direction every 2 hours for 12 hours, before and after. (True force, magnetic direction.)

Before	After
2	2
4	4
6	6
8	8
10	10
12	12

11. Current experienced at time and for 2 days before and after.
12. Where bound at time of sighting.
13. Temperature of water at time of sighting.

This form would call attention to the essentials of the information required. The forms could be printed with plenty of room on them for remarks, and in sending information by wireless, which should be encouraged, it would only be necessary to affix the information desired to a number representing the particular item in the table. It will be noted that all numerals are to be written out in the position; this to avoid error.

(To be concluded.)

* Write out in words.

The New Transatlantique Steamer Rochambeau.

In May last we published a view of the steamer *Rochambeau,* which was built for the Compagnie Générale Transatlantique at the Atlantic Works at St. Nazaire. She is second in size to the steamer *France* and *La Provence.* The general dimensions of the *Rochambeau* are as follows:

Length over all	597 feet 9 inches.
Length between perpendiculars	538 feet 6 inches.
Beam	63.8 feet.
Depth at the spar deck	43 feet 4 inches.
Displacement	70,300
Indicated horsepower	12,500
Designed speed	17 knots.

Mild steel is used in the construction of this vessel, and she is divided into thirteen watertight compartments. The double bottom, extends from end to end of the ship. The hull is divided by five steel decks, worked from stem to stern. Above the spar deck are the promenade and the boat decks.

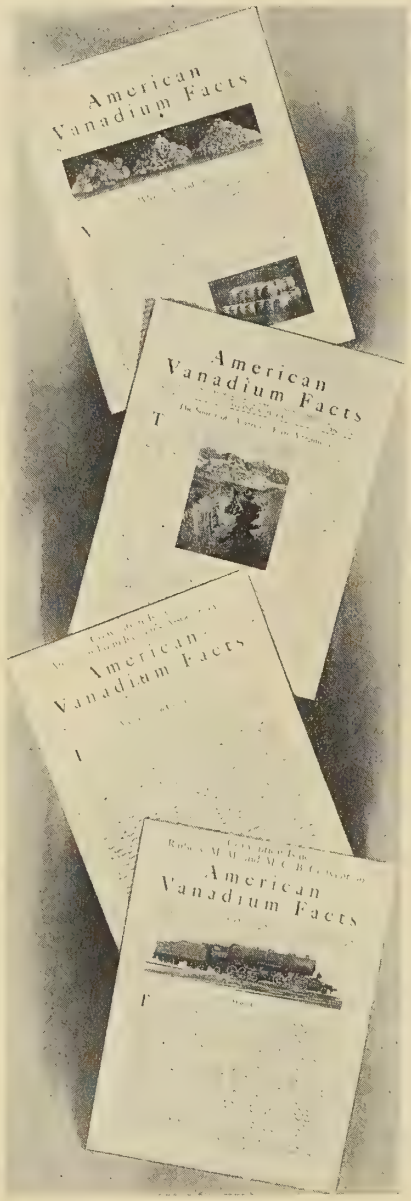
She was designed to carry first and third class passengers, as well as steerage, totaling 1,450 souls. She will run between Havre and New York.

A peculiarity of this ship is that she will be propelled by a combination of reciprocating and turbine engines, and this is the first time that such a combination has been tried in the French liners. She has two triple-expansion main engines of the three-cylinder type of the following dimensions: High, 33½ inches; intermediate, 49 inches; low, 56 inches; stroke, 29 inches. The revolutions per minute are 115. The turbines will be run at 350 revolutions per minute. The diameter of the turbine rotors is 68 inches. The reciprocating engines will drive the center shafts and the turbines the outside propellers. The main engines, when going astern, will exhaust directly into the condensers. Steam is supplied to both main and auxiliaries by a set of nine marine cylindrical boilers, 16 feet 9 inches in diameter and 11 feet 2 inches in length, carrying a normal pressure of 200 pounds. The grate surface will total 690 square feet and the heating surface 26,820 square feet. It is expected with this combination that the maximum efficiency will be obtained.

When they attempted to launch this vessel tallow was frozen on the ways and she could not be started, and the next spring tide had to be waited for.

American Vanadium Facts

Published monthly by the American Vanadium Company



This is the only regular publication in the world on the industrial application of Ferro Vanadium and Vanadium Alloys.

In an age of Steel-making that is largely characterized as the Vanadium Epoch, the contents of this monthly journal must be of vital interest to every man who melts, fabricates or uses steel, iron, or non-ferrous metals.

Buyers of metals are specifying Vanadium in their compositions because Vanadium increases the strength, toughness and life of all metals. Makers of steel and iron castings, forgings, and miscellaneous parts must get ready for the specifications.

Send us your name and correct address and you will receive this valuable publication free every month. It shows how to reach the high points in making steel, iron, brass, bronze and bearing metals.

American Vanadium Company

Largest Producers of Vanadium Alloys in the World

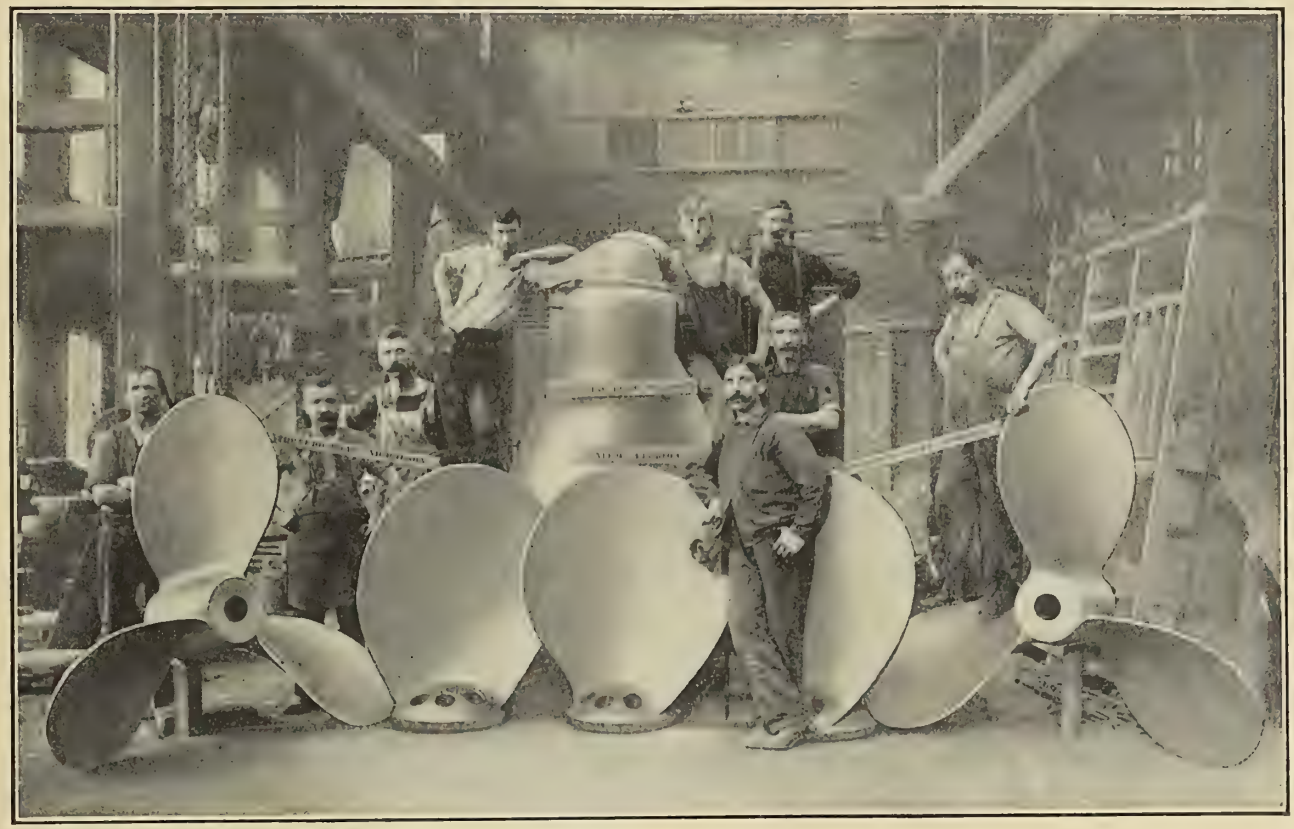
318 FRICK BUILDING, PITTSBURGH, PA.

Entire product sold by:

Vanadium Sales Company of America, 318 Frick Bldg., Pittsburgh, Pa., and Universal Vanadium Company, 30 Church St., New York City; 64 Victoria St., Westminster, London, England; 23 Rue de la Paix, Paris, France.

—PROPELLERS—

WHAT IS THE FIRST REQUISITE FOR A PROPELLER?
A HIGH GRADE COMPOSITION METAL.
WHAT ARE THE ESSENTIAL CHARACTERISTICS OF THIS METAL?
GREAT STRENGTH, TOUGHNESS AND NON-CORROSIVENESS.
HOW CAN THESE ESSENTIALS BE GUARANTEED?
BY USING VICTOR VANADIUM BRONZE.



Like few other high grade compositions, Victor Vanadium Bronze is non-corrosive in salt water. It is very strong and tough, as well as ductile, showing a tensile strength of 70,000 lbs., and an elastic limit of 40,000 lbs., and it has a very close molecular structure.

Probably one of the most distinctive points is the light weight of Victor Vanadium Bronze compared with other bronze compositions possessing high tensile strength. The specific gravity of Government bronzes runs from 8.75 to 8.85, while that of Victor Vanadium Bronze is only 7.84, a decrease of over 10%.

Specify Victor Vanadium Bronze in your propellers.

VANADIUM METALS COMPANY

GENERAL OFFICES - - - - PITTSBURGH, PA.

FOUNDRIES - - - { EAST BRAINTREE, MASS.
{ GROTON, CONN.

THE SPERRY GYRO-COMPASS.

As ships are constructed more and more of steel, wood being replaced, and especially as they have become larger, it has been found that the magnetic compass becomes more and more of a problem. In earlier times the earth's magnetism, upon which the magnetic compass depends, had no difficulty in finding its way directly to the compass needle, but now, with steel ships, the ship itself becomes strongly charged or magnetized from the earth's magnetism, and thus steps in as a powerful factor and tends to control the needle. The ship itself thus becomes a great magnet, and it is with much difficulty that the needle is brought to be influenced even to a small extent by the earth's magnetism, as the needle naturally tends to point to the induced magnetic poles upon the ship

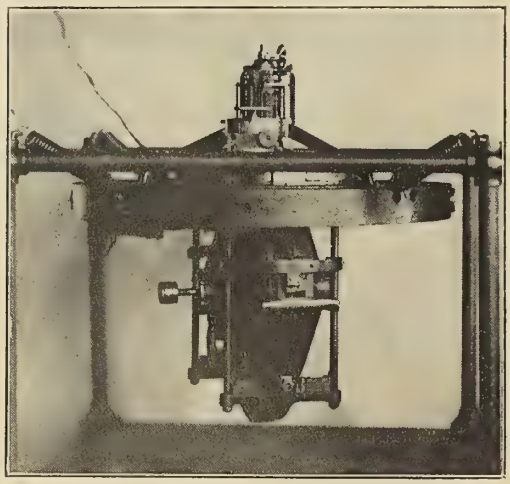


FIG. 1.

which are comparatively close by, and thus move with the ship rather than point to the earth's magnetic pole.

Again, the magnetic pole is nearly 1,000 miles removed from the North Pole, so that a compass needle in Iceland points westwardly. The compass is 32 degrees out on the northern steamship course between England and America. There is only one place out of ten thousand different positions upon the earth's surface where the needle can point north. These spots, together with all magnetic meridians, are constantly moving and changing locus. The object of the non-magnetic yacht *Carnegie* is to explore in attempts to relocate many of these meridians which are known to have shifted.

On warships the uncertainty of the compass is still further aggravated by the fact that gunfire, moving of turrets, or shifting of any gun or other piece of machinery on board are found to greatly disturb the compasses, rendering them unreliable. The starting up of the forward bank of boilers, and consequent heating of the funnel, has been known to throw the magnetic compass out 15 degrees.

Marine insurance reports show losses to the extent of many millions annually, traceable directly to compass failures and deviations which occur without the knowledge of navigation officers, especially in cloudy weather, when the navigator is without means of checking. Many attempts have been made to find some phenomenon outside of the earth's magnetism which may be employed to develop true direction or terrestrial position. In 1852 Foucault discovered that a rapidly spinning mass would detect the earth's rotation, and named the instrument the gyroscope (gyro to move, scope to measure). Great excitement was caused at the time in scientific circles, especially in the Royal Society of Great Britain, by Foucault's demonstration of this wonderful property of his gyroscope, but it has been left to an American engineer to devise simple and practical means whereby this wonderful instrument, known as the gyroscope, shall seek and persistently hold exact geographical north, indicating the exact position of the North Pole of the earth, and this regardless of where it stands upon the earth's surface or to what position it is transported; and what has been very much more difficult to accomplish, the machine is so constructed that it successfully withstands other forces, such as acceleration and decelaration pressures, jar and shock of gunfire, having recently withstood all of the salvos of the ten great 12-inch guns upon the Coronation battleship *Delaware* when they were all fired simultanously.

The practical machine develops a directive power which holds true geographically. Instead of pointing to the magnetic pole it points absolutely true to the North Pole of the earth.

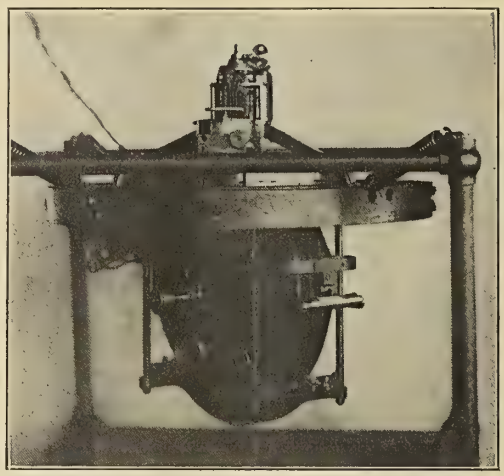


FIG. 2.

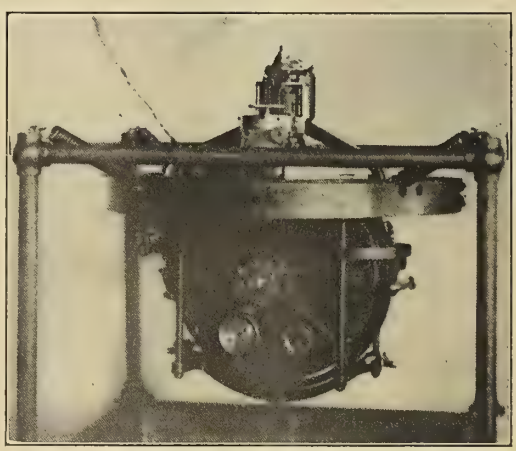


FIG. 4.

To add another chapter to the wonders of this instrument it may be stated that it derives its directive power by actually reaching down some 4,000 miles and "laying hold," as it were, of the exact axis of the earth a noumenon, this imaginary line passing through the earth's center of gravity about which the earth revolves, and even though it is compelled to act at this great distance, yet in protracted sea trials, which we are informed have been of the most searching character, through which the United States navy has recently carried this compass, it was found to have a directive power of about 7,000 times the directive power at the Equator, and no force was found that could tear it away from its dead north indicating direction, no matter how many times the ship was swung entirely around the circle or back, or how great a storm the ship was in, or how much motion or jarring the ship had or

tremendous vibration through gunfire. No force was discovered which could turn it aside from its wonderful tenacity of purpose.

The gyro navigation equipment consists of a master gyroscopic compass which is located below decks. It is about 1½ feet in diameter and about the same in height. It contains a small spinning-wheel, which is electrically driven, and requires about the same current as would operate two or three ordinary incandescent lamps. The little wheel operates on two small ball bearings, which require practically no attention and maintain a life of many months in constant use. The wheel is enclosed and can be seen depending from a large horizontal compass card below the cardian or suspension ring in Figs. 1, 2 and 3. These figures are of added interest, owing to the fact that this group of photographs constitutes a moving picture, indicating the exact motion one sees the gyro-compass make when the ship is turning around in a circle or through 90 degrees.

In Fig. 1 the casing containing the gyro-wheel, or gyroscope, is seen edgewise to the observer; in Fig. 2 the forward edge has swung around somewhat to the right, and in Fig. 3 still further to the right, nearly 90 degrees from the first position. Although the wheel and casing are seen to move, this is only apparent. The facts are: the spinning-wheel and the casing are standing absolutely still in space, pointing to the North Pole, while the walls of the room and the ship as a whole move about it. Although this master compass down in the hold of the ship is possessed of a compass card and is directly used for navigating purposes, yet it need not be so used, because the little mechanism seen on top

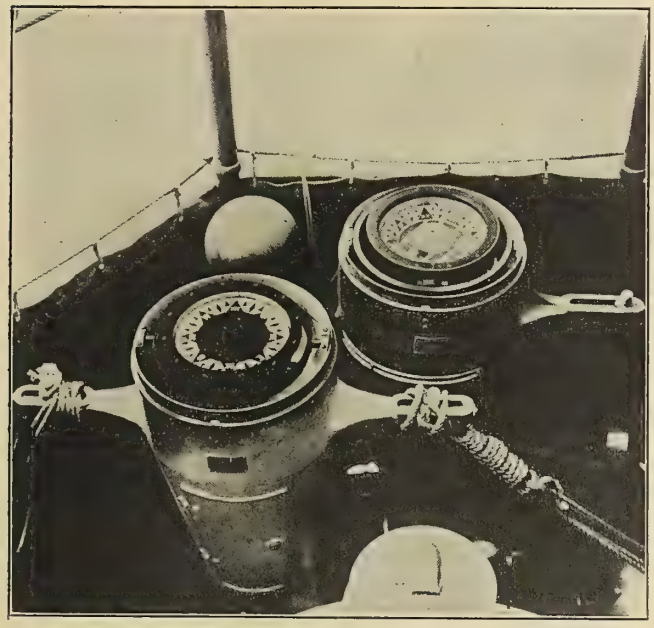


FIG. 4.—GYROSCOPIC REPEATING COMPASS ON THE BRIDGE OF THE DESTROYER DRAYTON

of the compass, in Figs. 1-3, constitutes a transmitting device whereby all of the directive movements, even to the most minute, are instantly transmitted to a number of repeating compasses located on the bridge, in the wheel-house, or in the chart room, and, in fact, wherever else desired throughout the ship, a simple electric wire connecting them for transmission of the directive forces. Fig. 4 shows the position of the gyroscopic repeating compass in its own binnacle, the one to the left arranged close to a magnetic compass, on the bridge of the United States destroyer *Drayton*, one of the fleetest ships in the United States navy, which was designated to make the initial sea trials.

These photographs were taken in New York harbor, where the magnetic variation is about 9 degrees. There was also a magnetic ship deviation at this particular heading of several degrees, and their sum is exactly the difference that can be seen between these two compass cards, the gyro-compass holding to the geographical meridian—dead north—whereas the compass card is pointing 12 to 15 degrees away from true north. It was found at the end of the trials and after the repeating compasses had changed their positions a great many hundred thousand times that there still remained no difference between the readings of the master and repeating compass.

In the case of the *Drayton* the demands of the United States Navy Department were unusually rigid, and the master compass was required to perform its full function when placed

FIG. 5.—SPERRY GYRO-COMPASS ON THE STEAMSHIP PRINCESS ANNE.

away down in the hold of the ship; in fact, in the lowest part, just on top of the keel in the powder magazine, surrounded on every side by solid steel walls, where the earth's magnetism could not penetrate nor have ever been available to the slightest degree, and where no mariner would ever think of placing or atempting to operate a magnetic compass.

SEA TRIALS ON NAVAL VESSELS.

The series of sea trials referred to above has resulted in establishing many points of interest regarding gyro-navigation, some of which are noted below.

All readings of all azimuth circles or indicators, whether master compasses or repeating compasses, are held dead upon the meridian, thus avoiding all necessity of calculation or reference to charts in translating the observations; especially is this emphasized when it is remembered that prior to Mr. Sperry's work, with the reading of the gyro-compass indication, at least three other simultaneous observations had to be made, namely: The ship's speed or headway; the ship's course, and especially the meridional component of the course; the latitude, and then calculations made, or charts or tables consulted before the proper correction is ascertained and position of the meridian found, this being hitherto the universal practice with gyro compasses.

The amount of correction, and whether it is positive or negative, which is being at all times automatically introduced by virtue of the peculiar structure of the compass itself, is given on a special scale which can be read whenever desired.

Directive power of at least 200,000 dyne centimeters, about 7,000 times the magnetic, in the east and west position at the Equator is available with less than 9,000 revolutions per minute. The comparatively low speed of the Sperry gyro-compass is advantageous on a number of important accounts, among which are integrity of bearings and rendering the machine low in point of maintenance and attention required, as well as low in power absorption during operation, and also important on account of quick starting.

Gyroscope compasses have a very long period of swing or oscillation. This period is in direct proportion to the gyroscopic moment or the directive power of the compass, and one great difficulty in developing a compass with as high a directive factor as that of the Sperry compass has been to devise means whereby this period of oscillation can be brought down within practical limits. It is just here that engineering skill is displayed in introducing an entirely new phenomenon into the art of gyro-compasses, viz.: positive orientation, whereby the period has been reduced by about 800 percent and becomes a perfectly practicable operative quantity. All Sperry gyro-compasses have this feature.

All azimuth indicators, scales or pointers, either master, repeating or recording, including those for navigational purposes, and also those for ordnance, are positively driven and possessed of a large and positive torque factor, whereby all sensitiveness of indication is removed and the instruments freed from disturbance from gunfire, etc.

Definite provision is made for simultaneous connection and operation of other special automatic instruments, including the automatic pelorus azimuth indicator, recording and other various navigation and ordnance instruments now in operation on the battleships of the United States navy. These function properly by virtue of the non-lag mentioned in the previous paragraph.

The entire circle in azimuth is turned in less than one minute instead of six minutes heretofore required; not that some ships will turn an entire circle in this time, but many motions requiring accurate indication without lag are made at least at this rate, and are thus made instantly available for accurate steering, and especially for other important purposes in which their use has been established.

All repeater scales or cards hold to their positions instead of being constantly on the move. A method has been discovered and adopted giving the time of rest, very large as compared with the time of taking up the new position, nearly five to one, thus greatly facilitating taking of observations.

Artificial orientation is possible and conveniently arranged. The combination with the azimuth-moving element of the instrument of an indicator mounted upon the freely-moving wheel frame, combined with handles by means of which the instrument can be almost instantly set upon the meridian, and whereby even the most ordinary attendant can instantly discern that the apparatus is in condition of permanency during the operation of setting, and will maintain its indication for an indefinite period if the setting be correct.

As correlative to the last feature is the fact that these particular features of the equipment constitute an apparatus by means of which the position of the meridian can be quickly found or determined when its position is not known without waiting for the instrument to come to the north and settle itself, by means of which this setting operation can be very materially hastened. On the battleship *Delaware* the meridian was located on test by Engineer Ford in about twelve minutes while the boat was maneuvering constantly, and where, the gyro-compasses being down very low in the ship, the location of the north was entirely unknown to Mr. Ford.

Provision is made for running the spinning-wheel in vacuum, whereby a material saving of electrical energy is effected, especially when the compass is operated on submarines where this energy must be furnished from storage batteries. It is found that a saving of fully four-fifths of the energy is in this way effected.

The advantage of vacuum operation was furthermore demonstrated on both the earlier sea trials where the current was off for periods up to three-quarters of an hour, and in that time the speed had not diminished materially, and the directive power had kept up so that the meridian was held throughout; under atmospheric pressure the gyro-wheels would have run down much more rapidly, fully five times as rapidly for top speeds, especially when this wheel is used to generate an air blast.

Electrical energy is saved in not being employed to develop an air blast or any other extraneous forces, and a point of the greatest importance is secured, namely, accumulations of grit, dirt and foreign matter are thus prevented from reaching the interior of the most important part of the equipment, including the main journals, which by the Sperry arrangement remain hermetically sealed and are found not to require attention and cleaning nor even oiling except about once monthly.

The suspension system is purely mechanical, consisting of a short, stout torsion suspension of pianoforte wire; it is possessed of very great sensitiveness—this factor being such that the wheel when at rest will make upwards of thirty vibrations across the hair line in coming to rest when pulled aside only one degree and released. All mercury or other volatile liquids or fluids are eliminated, and the supports are reduced to a few simple and purely mechanical factors. The elimination of mercury is considered by those experienced in its use to be a positive and important step in advance. In operating without mercury the drawing around of the compass from the true north through the well-known drag or reaction of the swirling of the mercury bath upon the float is entirely avoided. Certain compound motions of the boat are very likely to set up these swirls, especially where the mercury is present in the form of a ring or annulus and when the float supplying the card is also annular, thus introducing serious errors without giving the slightest warning or alarm. Deflections as high as 10 degrees have been noticed due to this cause.

Integrity of circuit is obtained because the electric circuits within all the repeaters are permanently closed, and there are no traveling or moving contacts, commutators or the like. All wiring and parts are soldered and permanent and cannot get out of order nor require attention. The azimuth controllers or actuators are all in duplicate and separately removable and replaceable, and may be removed, inspected or adjusted at will without in the slightest interfering with the operation of the instrument. The master compass occupies comparatively small space, and requires no adjustment, addition and removal of weights with changes in latitude or in changing from north to south latitude, this difficulty being entirely overcome by functions which are automatically introduced.

The master compass is entirely independent of position in the ship with reference to the ship's axis of oscillation, and reports show that it works equally well and with equal precision in any position. The oil equalization system, connected with the main gyro bearings, does away with inequalities and out-of-balance conditions arising through unequal oil consumption. Perfect equilibrium is at all times automatically maintained, both oil receptacles being also automatically refilled through a single opening, and this only at very infrequent intervals, the whole rotor system requiring very little attention.

The repeating-compass operating mechanism is made light and small, with a view to its being placed when required in an

extremely light and small "portable," and is supplied with a light flexible cable of some length for use in submarines in connection with the different positions and stations requiring the presence of the commanding officer. Wherever the commanding officer is he is thus supplied with a precision instrument operating with an accuracy of a small fraction of one degree, aiding greatly in the accuracy of his aim and in determining the exact moment for the discharge of his torpedoes, to say nothing of the advantages in navigation as such, especially in connection with accurate maneuvering.

SEA TRIALS OF THE SPERRY GYRO-COMPASS ON THE PRINCESS ANNE.

A five-day test of the Sperry gyro-compass was made recently on the steamship *Princess Anne,* a vessel of about 2,200 tons, belonging to the fleet of the Old Dominion Line, plying between the ports of New York and Norfolk, Newport News and Old Point, Va. The tests were conducted in the presence of Mr. John Bliss, of John Bliss & Company, New York City, compass adjusters of the port of New York, whose sun instrument and chronometers were used. The master compass was set with its motor generator in the steering engine room of the vessel, two decks below the bridge. The repeating compass was placed in a tripod, furnished by John Bliss & Company, a few feet astern of the ship's standard compass on the bridge. These were connected by wire cable, ordinary lamp cord, No. 18, being employed. The gyroscopic compass persists with great rigidity in the meridian, showing the very minutest deviation of the boat. The repeating compass follows these deviations with every change of one-third degree. A great many comparisons were made, and it was always found that the repeating compass retained permanently its original "set" and never varied therefrom. At the finish the correspondence was found to be perfect between the two compasses, although it is estimated that there were over a half million changes in azimuth made by the repeating compass. No supplies were used on these trials except about two tablespoonfuls of oil in the compass supplied to the motors-bearing equalizer pipe. The only adjustment found necessary was the original adjustment of the lubber line to bring it in correspondence with the ship's axis. On one occasion the current was turned off by accident while operating the headlight. After it had been off about twenty minutes it was discovered and turned on again, but the speed of the gyroscope had not come down very much and the directive power had not been sufficiently impaired to be discernible. It was immediately compared with the other compass and checked exactly with the proper difference. The compass required practically no attention.

During these trials the ship rolled considerably. Its period seemed to be between ten and twelve seconds. Some rolls were about 40 degrees total arc, a great many 32 degrees, and one was measured to the leeward 22 degrees from the vertical. These motions of the boat seem to have no effect upon the operation of the compass. While swinging in the harbor of Newport News with a hawser at the bow of the ship and the propeller reversed, there were various resonant points in the period of the spring of the boat when the boat shook very vigorously. Upon this occasion, Commander A. M. Cook, of the Ordnance Bureau, was present, and reported that this vigorous shaking, which seemed at times of the magnitude of 8 inches up and down and in period with the engine vibrations, was very much more severe on the compass than heavy gunfire would have been on a warship with the compass in, or about, the engine-room. These motions seemed to have not the slightest effect upon the instrument or its accuracy.

During the trip a speed of only 6,000 revolutions per minute of the little gyro-wheel was maintained, developing all the directive power that was necessary, holding both the master compass and the repeating compass practically absolutely upon the meridian. The course laid between magnetic variations of about 9 on the north to 4 7/10 on the south end of the course. During the voyage South the magnetic compass was seen to gradually close in, bringing the needle more nearly in line with the readings of the gyro-compass, and on the return course the magnetic compass gradually pulled away from the readings of the gyro-compass. This observation was of considerable interest to many.

THE U. S. COLLIER NEPTUNE.

The above-named ship was built by the Maryland Steel Company, Sparrow's Point, Md. The contract was awarded Sept. 23, 1909, the price of construction being $889,600 (£182,000), and time of completion 20 months. Standardization trials were performed July 26 last and the 48-hours' full-speed trial on July 27, 28 and 29.

The *Neptune* is a sister ship of the *Cyclops,* completed on Oct. 28, 1910, by the William Cramp & Sons Ship & Engine Company of Philadelphia. Both of these colliers were authorized by the Naval Appropriation Act approved May 13, 1908. The principal contract requirements stipulated were: An average speed of the vessels on a continuous 48-hours' trial of 14 knots when carrying a full load of 12,500 tons of coal, inclusive of bunkers; 100 tons of reserve feed water, 20 tons of drinking water, 130 tons of stores, and with equipment complete. Besides the foregoing it was stipulated that the coal consumption for all purposes should not exceed 1.8 pounds per indicated horsepower per hour, figured on the power developed by the main engines. Both of these vessels were built in conformity with the rules and regulations of the American Bureau of Shipping and the United States Steamboat Inspection Service.

The essential data of hull and machinery, with especial reference to the *Neptune,* are incorporated below:

Length between perpendiculars	520 feet
Length, over all	542 feet 10 inches
Length on load waterline	529 feet 10 inches
Beam, extreme	65 feet 3 inches
Beam on load waterline	65 feet
Mean draft, load	27 feet 7⅝ inches
Displacement on load draft	19,440 tons
Block coefficient	.734
Material	Mild steel

The machinery installation of the *Cyclops,* partly described in a previous issue of International Marine Engineering, consists of twin-screw, three-cylinder, vertical triple-expansion engines, 48 inches stroke, cranks at 120 degrees, and piston valves on all cylinders. The machinery installation of the *Neptune* consists of twin-screw Westinghouse turbines, connecting to the line and propeller shafting by Melville-Macalpine reduction gears. The main boilers, as in the *Cyclops,* are three double-ended, cylindrical return fire tube, with one single-end Scotch donkey boiler.

Condensing surface in the *Neptune,* distributed in two main cylindrical surface condensers and one auxiliary condenser, totals 11,700 and 1,000 square feet respectively. The main airpumps are of the Le Blanc-Westinghouse type. Dynamos, centrifugal pumps and fans are all engine driven. The following table gives speed in knots, revolutions per minute, horsepower, etc., on trials:

	CYCLOPS.
Speed in knots	14.61
Revolutions per minute	92.26
Average steam pressure at boilers	192.00
Vacuum, inches	27.1
Collective indicated horsepower of main engines	6,705

Pounds of coal per indicated horsepower per hour (main engines only)	1.48
Displacement at middle of trial	19,095 tons.

NEPTUNE.

Speed in knots	12.926
Revolutions per minute	119.5
Average steam pressure at boilers	173.00
Vacuum, inches	28.30
Collective brake-horsepower of turbines	5,409
Equivalent indicated horsepower of turbines	5,879
Pounds of coal per indicated horsepower per hour	1.791
Average displacement	19,531 tons.

In commenting on the preliminary contract trials of the *Neptune* the following citation is made from the August number of the *Journal* of the American Society of Naval Engineers: "On the 48-hour full-speed and endurance trial the contract speed of 14 knots was not maintained, due to the use of very inefficient screws. * * * The reduction gear worked very satisfactorily on the trials with but little noise and no appreciable vibration."

While the Navy Department has decided to take over the *Neptune* temporarily and place her in service at once, so as to lose no time in gaining valuable experience in the operation of the reduction gear, it is at the same time understood that the contractors have made arrangements to replace the present turbines with others expected to fulfill all requirements. New screw-propellers are also now being made and will be finished shortly. Six months at least, however, will be necessary for the manufacture and installation of the new turbines.

It will be of interest to the readers of International Marine Engineering to learn that the *Jupiter,* a third collier of identical dimensions and requirements as those which refer to the *Cyclops* and the *Neptune,* now building at the Mare Island Navy Yard, California, will be equipped with an electric system of propulsion. The contract for the installation in question has been given to the General Electric Company of Schenectady, N. Y., and will be along lines described by Mr. W. L. R. Emmet, in a paper read before the American Institute of Electrical Engineers, the contents of which were given in an abridged form in the July number of this magazine.

Much instructive and interesting data will be afforded the engineering profession when the comparative results of the three vessels here referred to become available, but the liberal policy pursued by the Government in this regard will be valuable not only to the engineer, but will at the same time be commercially useful.

SINGLE SCREW STEEL COLLIER SUFFOLK.

The New York Shipbuilding Company, Camden, N. J., has recently completed and delivered to the Coastwise Transportation Company, Boston, Mass., a steel screw collier of the following dimensions:

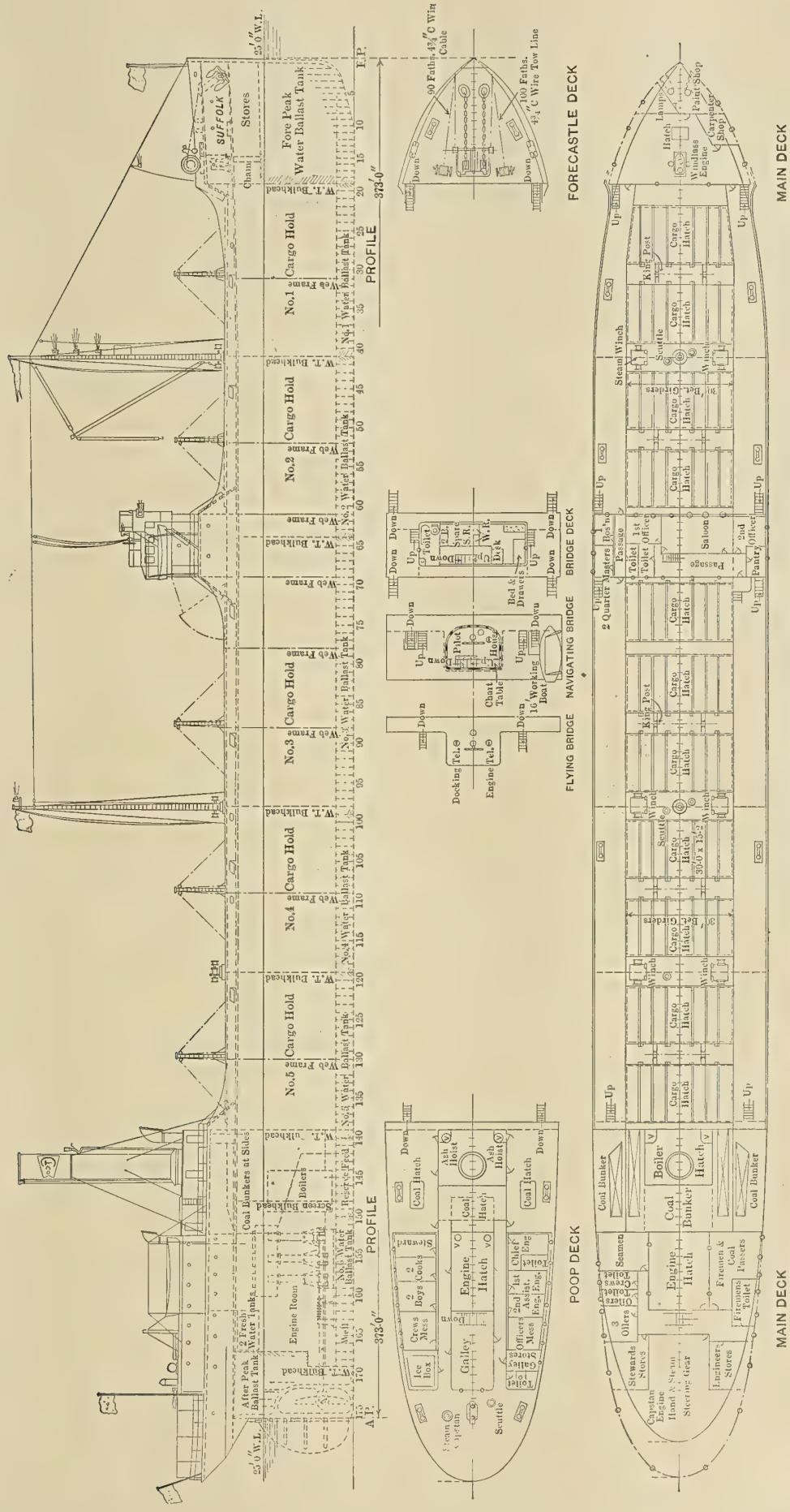
Length between perpendiculars	373 feet.
Beam, molded	50 feet.
Depth, molded	32 feet.
Draft, loaded	25 feet.
Cargo carried at this draft	7,200 tons.
Gross tonnage	4,718 tons.
Speed at sea, loaded	10 knots.

The vessel is of the same type as the *Coastwise* and *Transportation,* built by the New York Shipbuilding Company for the same owners last year; the dimensions and deadweight, however, have been increased. The construction is in accordance with the requirements of the American Bureau of Shipping.

The vessel has a single deck of steel, with poop 80 feet, bridge 17 feet, and forecastle 34 feet long, seven steel watertight bulkheads, two pole masts, straight stem and semi-elliptical stern. A deep double bottom is fitted all fore and aft for the carriage of water ballast, and particular attention has been paid to the construction of this part of the vessel; the plating being of extra strength and fitted flush; no wood ceiling is fitted. The five cargo holds are entirely clear of beams and pillars, the deck being supported by deep arched beams and web-frames placed midway between the watertight bulkheads; a continuous trunk, 24 inches deep by 30 feet wide, is carried on the upper deck for the full length of the cargo spaces. Large steel cargo hatches are in the top of this trunk, eleven in all. Six steam winches are fitted in connection with five pairs of king posts for raising the hatch covers and securing them in place when open. A cargo boom is located on the fore mast for handling stores, etc. The coal bunkers are at the sides of the vessel in the boiler room and in the poop 'tween decks, with hatches on the poop deck and pockets leading to the fire-room. The peaks are both arranged as water-ballast tanks. The accommodations consist of a midship deck-house on the bridge deck for the captain's stateroom and spare room, with a pilothouse over; the saloon officers' and petty officers' berths, pantry, toilet, etc., are in the bridge; the engineers, cooks, steward, messrooms, refrigerator, toilets, galley, etc., are in the houses on the poop deck, and the oilers, seamen and firemen are berthed in the poop abreast the engine casing.

The steam windlass is fitted with warping ends and located on the forecastle deck, with the engine below in forecastle.

COASTWISE TRANSPORTATION COMPANY'S NEW COLLIER SUFFOLK.



OUTBOARD PROFILE AND DECK PLANS OF COLLIER SUFFOLK, BUILT BY THE NEW YORK SHIPBUILDING COMPANY OF CAMDEN, N. J., FOR THE COASTWISE TRANSPORTATION COMPANY, OF BOSTON, MASS.

The steam capstan is on the after end of the poop deck, with the engine below. The steam steering gear is on the upper deck abaft the engine casing, with connection to the steering stations in pilothouse and on navigating bridge; auxiliary hand-steering wheels are also provided. The propelling machinery is placed aft, and consists of one triple-expansion, inverted reciprocating engine of about 2,100 indicated horsepower, and two single-ended Scotch boilers having a working pressure of 175 pounds. The vessel is intended for the coastwise coal-carrying trade between Baltimore and Boston. Loading and discharging gear is not fitted on board, the two terminal points being arranged with these facilities.

GAS ENGINES; THEIR DESIGN AND APPLICATION.

BY E. N. PERCY.

(*Continued from page 352.*)

The effect of compression is threefold, first upon horsepower, second upon economy and third upon design. High compression increases the horsepower because in order to have high compression it is necessary to have a proportionally small clearance, which permits the egress of a large portion of the burnt charge and the intake of a large fresh charge, obviously resulting in more horsepower.

To find the limit of velocity, we know that pressure varies inversely as volume with gases. When these gases are suddenly compressed work is done, which is converted into heat which is expressed by rise in the temperature of these gases. A correction is necessary, as it is obvious that with temperature there would be increased pressure, hence some modifying factor must be introduced into the well-known formula: $P\,V = C$. This has been established with very fair accuracy with theoretical conditions, such as isothermo compression, or compression with a rising temperature and adiabatic compression, or compression at a constant temperature, the heat being abstracted at the same rate as added. This formula may be employed with fair accuracy for air compressors working under known conditions, but the constants for gas engines are impossible to derive theoretically except by assuming certain conditions which cannot be proved to exist in the gas engine.

The acknowledged proper form for an equation for compression is $P\,V^n = C$. From an enormous number of experiments the value of n is found to vary from 1.3 to 1.5; 1.4 being accurate enough for all practical purposes and normal designs. The most practical way to handle this formula is obviously by the aid of logarithms, it being somewhat awkward on the slide rule.

PRACTICAL METHODS OF FINDING COMPRESSION.

The true compression of an engine can only be found approximately, and then only for given conditions. Careful calculations for given conditions will indicate the compression more closely than it can be found by any instrument, providing the conditions in the engine and in the calculations coincide. The indicator card, when taken with the proper instruments, shows not only the amount of compression but also its instantaneous character and the extremely instantaneous character of the maximum pressure about it, being in most cases a sharp point far above the rest of the diagram; at the same time an engine having a throttle governor or a governor which in any way alters the charge will so change this compression at any variation of load that it is entirely a matter of judgment as to what is the true compression of the engine, it being usual to assume the maximum compression as the true compression. But this is seldom the case so far as averages are concerned.

No method could be more unsatisfactory than that of putting a gage on the cylinder to learn the compression, as when such a gage is used and the engine turned by hand the compression indicated is barely two-thirds of the true compression. On the other hand, if a gage with check valve and receiver be used, and the engine operated at full speed by an outside source of power, the compression is still incorrect because the cylinder valves and piston are not so highly heated as in the case of an engine under full operation.

In a 6¼-inch by 7½-inch single-cylinder engine running at 400 revolutions and under normal conditions a compression of 75 pounds was shown both on the indicator cards and by careful computation. The steam gage test carefully applied for tests extending over an entire day with two gages, check valves, and so forth, operating the engine from outside power, also turning slowly by hand, show the compression to vary from 50 to 57 pounds.

In general, as a rough average, it may be stated that for a given relation the compression in a gas engine under operative conditions is anywhere from 5 to 20 percent more than a carefully cooled air compressor. Hence to determine compression for particular conditions one is dependent upon either one of two methods, calculation or the indicator card.

The effect of compression on economy is best shown by actual test, as summed up in Table 4. This table quotes from tests of Prof. Burstall, all on the same engine at Birmingham, with gas, as given in the proceedings of the Institute of Mechanical Engineers, 1898.

It will be noted from this table that the heat efficiencies and the total efficiency increases with the compression, also that the clearance volume approximated the compression amount when calculated $P^{1.4} = C$.

By referring to Table 5, in which four particular compressions have been experimented with, each with a different volume of air to volume of gas, the effect of each upon the heat efficiency and the other factors may be noted.

Practically, compression should be as high as possible for the sake of technical economy. The combustion chamber should be as nearly globular as possible. The means of ignition should be as near to the center of this globe as possible, so that explosion might be provided on all sides. The piston speed should be as high as possible in order that the loss, due to radiation, be reduced to a minimum, and the stroke should be long enough to allow complete combustion.

Opposed to these theoretical requirements and their relations to combustion are the requirements or reliability and durability representing commercial efficiency. These requirements call for ample bearings, slow speeds, moderate compression, ample cooling surface and great capacity for governing, regardless of economy. Thus any design which goes to radical ends to attain technical economy is apt to depart from the requirements of commercial economy and its field of usefulness ceases to exist. Among the more or less radical steps to obtain all the advantages of high compression without infringing upon these immovable commercial requirements are the injection of water, off-set cranks, the absence of fuel until after compression and slow-burning mixtures.

The water injection engine has been used in many forms, some engines using it in the form of steam after evaporation in the engine jacket. These engines have, in addition, a very high thermal efficiency, but for reasons doubtless practical and founded on experience do not compress above 60 or 70 pounds and are designed to burn oil exclusively. Off-set cranks, while not practically allowing a very high compression, diminish or eliminate the shock incident to greatly advanced spark or rather high compression. Of the many engines which compress pure air and afterwards igniting the fuel, the Diesel seems to be the only one aggregating more than 100 pounds compression; hence it cannot be stated that the fuel value of compression is utilized by carburetors of the ordinary engines.

(*To be continued.*)

TABLE 4.

Test No. in Order of Merit.	Revolutions per Minute, Mean.	Power. I. H. P.	Power. B. H. P.	Heating Value of Gas Thermal Units per Cubic Foot.	Gas Consumed per Hour Including Ignition. I. H. P. Cubic Feet.	Gas Consumed per Hour Including Ignition. B. H. P. Cubic Feet.	Thermal Units Consumed per Minute. I. H. P. T. U.	Thermal Units Consumed per Minute. B. H. P. T. U.	Compression in Pounds per Square Inch, Absolute Pounds.	Volume Air to Volume Gas.	Initial Pressure in Cylinder Absolute Pounds per Square Inch.	Exhaust Gases Analysis by Volume Percent. CO_2.	Exhaust Gases Analysis by Volume Percent. O	Clearance Volume to Total Cylinder Volume Percent.	Temperature Jacket Water Out. Degrees F.	Original Test No.	Heat Efficiency Percent Taking. I. H. P.	Heat Efficiency Percent Taking. B. H. P
1	107 min.	5.10 max.	4.13 max.	598	20.3 min.	25.1 min.	202 min.	250 min.	103	8.6	201	6.8	8.6	25 min.	144°	15	21.0 max.	17.0 max.
2	156	2.87	2.32	608	23.3	28.8	236	291	72	9.5	171	6.0	9.6	41	145°	7	18.0	14.6
3	149	2.56	2.07	595	23.8	29.4	236	292	105	10.8 max.	135	3.6 min.	11.6 max.	25 min.	152°	17	18.0	14.5
4	155	2.61	2.11	605	24.0	29.6	242	298	80	10.1	161	5.2	10.8	36	160°	10	17.6	14.2
5	154	2.50	2.01	586 min.	26.5	32.7	259	320	83	8.7	203	6.5	7.0	37	134° min.	11	16.4	13.3
6	161	2.65	2.15	617	25.6	31.6	263	325	62	8.0	211	7.6	6.4	49	144°	2	16.2	13.1
7	204 max.	3.79	3.07	610	26.9	33.2	273	338	65	8.3	167	7.2	7.6	46	144°	5	15.6	12.6
8	158	2.69	2.18	635 max.	25.9	32.0	274	339	64	8.4	171	7.2	7.4	49	148°	3	15.5	12.5
9	164	2.79	2.26	607	27.3	33.7	276	341	64	7.1	203	8.0	5.2	49	146°	4	15.4	12.4
10	158	2.61	2.11	606	27.7	34.2	280	346	76	7.1	230	8.2	5.8	36	149°	9	15.2	12.3
11	117	1.84	1.49	603	28.2	34.8	284	350	86	10.4	179	6.2	9.4	37	140°	13	15.0	12.1
12	158	2.44	1.97	600	29.7	36.7	296	367	74	7.2	237	8.2	6.6	41	151°	8	14.4	11.6
13	118	1.60 min.	1.30 min.	606	31.1	38.4	313	388	102	9.2	210	5.4	10.6	25	141°	14	13.6	11.0
14	157	2.48	2.01	625	30.3	37.4	316	390	105 max.	7.2	278	7.4	6.6	25	138°	16	13.4	10.9
15	118	1.72	1.39	614	33.0	40.8	337	418	52 min.	9.1	118 min.	6.0	10.0	57 max.	142°	1	12.6	10.4
16	155	2.52	2.04	621	35.1 max.	43.3 max.	363 max.	449 max.	83	5.3 min.	286 max.	9.3 max.	0.4 min.	37	168° max.	12	11.7	9.5
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

TABLE 5.

Test No. in Order of Merit.	Revolutions per Minute, Mean.	Power. I. H. P.	Power. B. H. P.	Heating Value of Gas Thermal Units per Cubic Foot.	Gas Consumed per Hour. I. H. P. Cubic Feet.	Gas Consumed per Hour. B. H. P. Cubic Feet.	Thermal Units Consumed per Minute. I. H. P. T. U.	Thermal Units Consumed per Minute. B. H. P. T. U.	Compression (Absolute) Pounds per Square Inch.	Volume Air to Volume Gas.	Maximum Pressure in Cylinder, Pounds per Square Inch (Absolute).	Exhaust Gases Analysis by Volume Percent. CO_2.	Exhaust Gases Analysis by Volume Percent. O.	Clearance Volume to Total Cylinder Volume Percent.	Temperature Jacket Water Out. Degrees F.	Original Test No.	Heat Efficiency Percent. Taking. I. H. P.	Heat Efficiency Percent. Taking. B. H. P
A. 1	201.5	4.41	3.29	547	24.9	30.9	227.0	281.7	55	7.8	131.2	7.28	8.57	0.57	151	A 4	18.7	15.0
2	207.5 max.	3.95	2.98	547	24.8	32.8	226.0	299.0	55	8.2	125.0	6.54	9.70	0.57	140	A 5	18.7	14.2
3	197.1	4.24	2.88	561	24.8	36.5	232.0	341.0	55	8.1	130.0	5.71	10.07	0.57	137 min.	A 6	18.2	12.4
4	201.3	3.75	2.55	561	25.6	37.6	239.3	351.5	55	8.6	122.0 min.	4.94	11.64	0.57	147	A 8	17.7	12.0
B. 1	199.8	4.72	4.07 max.	540	24.3	28.2	218.7	254.0 min.	71	6.8	177.0	8.00	6.25	0.45	153	B 3	19.4	16.7 max.
2	206.5	4.38	3.20	547	22.6	30.9	206.0	281.7	71	8.7	151.4	6.28	9.98	0.45	149	B 7	20.5	15.0
3	197.0	4.33	2.90	540	22.8	34.0	205.0	306.0	71	8.1	172.6	6.44	9.19	0.45	142	B 6	20.7	13.8
4	196.3	5.44 max.	3.93	540	24.8	34.4	223.0	309.6	71	5.4	224.5	10.55	1.05	0.45	146	B 1	19.0	13.7
C. 1	198.8	4.65	3.66	562	22.6	28.6	211.7	268.0	93	7.9	166.6	6.94	8.12	0.34	144	C 5	20.0	15.8
2	194.4 min.	4.21	3.17	562	22.8	30.3	213.5	283.8	93	8.5	167.0	6.44	9.20	0.34	149	C 6	19.9	14.9
3	198.7	5.27	4.04	562	26.3 max.	34.3	246.3 max.	321.2	93	5.0 min.	209.7	10.78 max.	0.82 min.	0.34	147	C 1	17.7 min.	13.2
4	202.2	3.43 min.	2.05 min.	562	22.7	38.0 max.	212.6	356.0 max.	93	10.3	130.8	4.72	12.45	0.34	155 max.	C 8	19.9	11.9 min.
D. 1	202.0	4.88	3.51	559	20.0 min.	27.9 min.	186.3 min.	260.0	124	8.4	200.0	6.93	9.09	0.25	151	D 5	22.7 max.	16.3
2	200.3	5.08	3.71	559	20.5	28.1	191.0	261.8	124	8.0	205.0	7.99	7.42	0.25	147	D 4	22.2	16.2
3	202.0	3.71	2.37	559	20.2	31.6	188.2	294.4	124	11.7 max.	170.6	4.59 min.	12.90 max.	0.25	147	D 10	22.5	14.4
4	196.7	4.57	3.41	547	24.4	32.7	222.4	298.0	124	6.8	260.0 max.	9.02	5.32	0.25	144	D 2	19.0	14.2
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

PRACTICAL EXPERIENCES OF MARINE ENGINEERS.

Incidents Relating to the Design, Care and Handling of Marine Engines, Boilers and Auxiliaries; Breakdowns at Sea and Repairs.

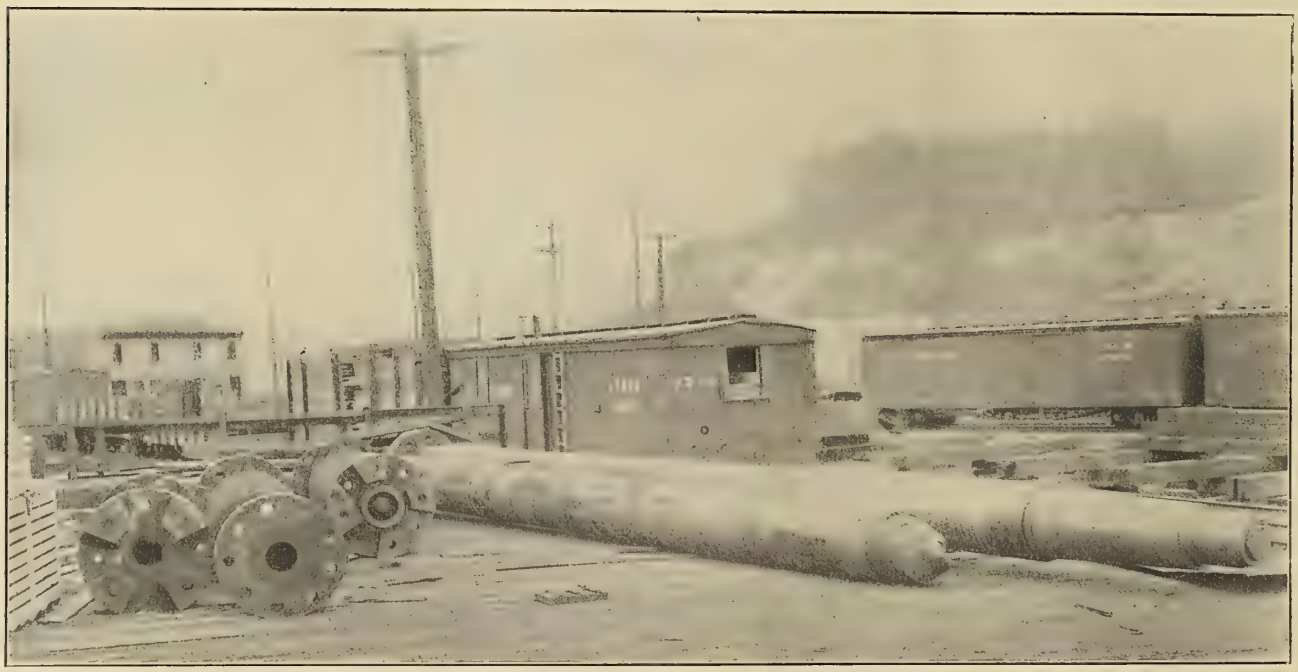
A Remarkable Series of Breakdowns.

EDITOR INTERNATIONAL MARINE ENGINEERING:

While on a recent voyage to the Orient, the Great Northern Steamship Company's 28,000-ton liner *Minnesota* had an extraordinarily bad run of luck, breaking both tail shafts, thrust shafts and short section line shafts in addition to losing her port propeller, and Chief Engineer George Allan and his assistants had an opportunity to perform some exceedingly skillful repair work, considering the conditions under which this was done. While the engineering force did several noteworthy repair jobs at sea, probably the most commendable was that to the port thrust shaft. It was accomplished under most severe difficulties, as the sea was very heavy and the ship was rolling. To make these repairs, as the shaft was cracked obliquely and also through the Verity coupling, three strands of cable were wound around the fracture. One strand was ⅜ inch, another ⅝ inch, and the third ¾ inch, the smaller strands fitting in between the layers of the larger. To hold these cables, which were drawn taut by turning the shaft and pulling the strands tight, six ⅞-inch pins were drilled into the shaft, preventing the cables from slipping off. On the face of the coupling a plate, 1¼ inch, was fastened, bolted through two couplings. Then a band was shrunk on the circumference of the coupling, with bolts 6 inches in length by 1½ inches diameter. This work took about two days, and is considered a noteworthy engineering accomplishment. That this repair job was thoroughly done is evident, as with it the steamer returned to Japan under the port engines alone, steaming probably 1,500 miles with this thrust shaft thus temporarily repaired.

The *Minnesota* was again in the Orient after having spent two months in Seattle, her home port, awaiting spare parts for her disabled shafting. While here the starboard fractured thrust shaft was replaced. A spare thrust shaft, two spare tail shafts and two spare short section line shafts were placed aboard before she departed again. These were furnished by the Midvale Steel Company, of Philadelphia.

On last New Year's day, while crossing the Pacific from Puget Sound to Japan, the Minnesota sustained the first of this remarkable series of mishaps. The port tail shaft broke about 5 feet from the end, the propeller dropping into the sea. Heavy head weather prevailed at the time, but the remaining 790 miles to Yokohama were steamed under the starboard engine alone. Thence she proceeded to Nagasaki under starboard engine, and at the latter port she entered drydock. The broken port tail shaft was withdrawn, and a survey disclosed no weakness or injury at the inboard end nor any other defect in the machinery. She remained in dock twelve days, during which the spare tail shaft, port side, was shipped, as well as new hub and blades.



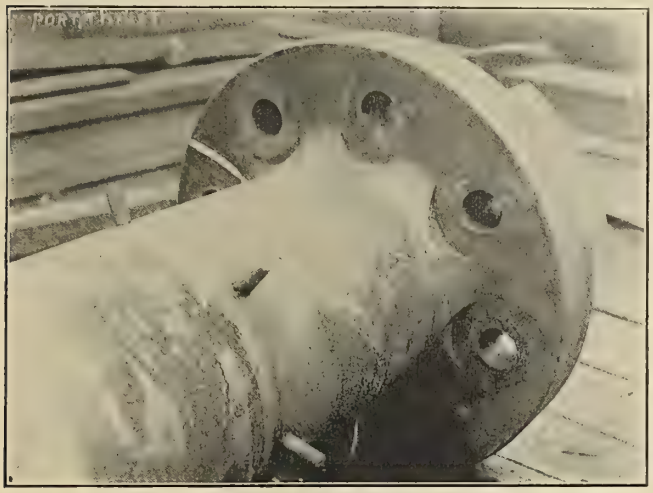
BROKEN SHAFTING FROM THE MINNESOTA ON THE DOCK AT SEATTLE, WASH.

Proceeding, the *Minnesota* went to Manila and Hongkong, the usual ports of call, and returned to Nagasaki and Kobe, sailing from Yokohama on her homeward passage Feb. 24. Previous to this, in steaming from Nagasaki to Kobe the big liner, with pilot aboard, struck bottom in Shimoneseki Straits, near Takase buoy. This brought the starboard engine up standing, bending two of the propeller blades while in contact with some hard substance. After grounding, the vessel slipped over the bottom into deep water, and continued to Kobe and Yokohama, no damage apparently having been done to the machinery. After leaving Yokohama, homeward bound, the steamer's machinery worked satisfactorily until, when she was 900 miles out, the engineers discovered a fracture in the port thrust shaft's Verity coupling. They began temporary repairs, as already described, the vessel meanwhile steaming on her course under starboard engine. About March 1 the

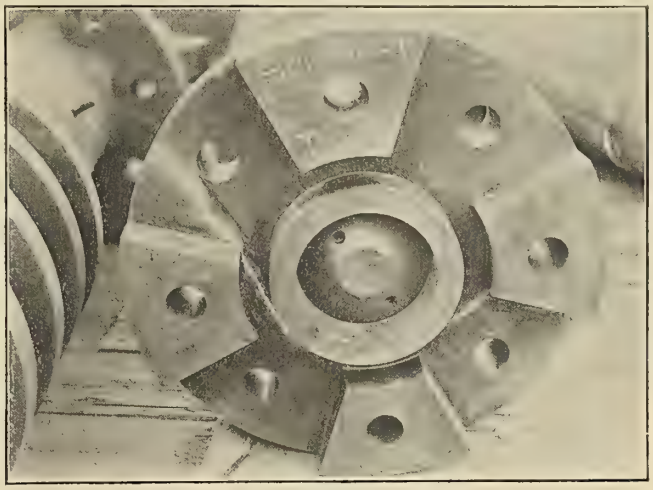
temporary repairs were finished, and the port engines again placed in service at 50 revolutions per minute.

It was just two hours and thirty minutes later that it was noticed that the starboard thrust shaft had given way, and examination proved that it was fractured through the Verity coupling. As the engineering force had no means or material by which they could shrink a band on this coupling, it was necessary to turn back to Yokohama, it being deemed unwise to attempt to make the remaining distance across the Pacific under port engine alone, the thrust shaft of which was temporarily repaired. She arrived at Yokohama nine days after repairs had been finished to the port thrust shaft, steaming under port engine for 1,500 miles, during which the repairs to the port thrust shaft held out well. A thorough examination at Yokohama was made of both engines, and it was discovered that in addition to a fracture in the starboard thrust shaft the starboard tail shaft was cracked at the inboard end. There was also a fracture in the Verity coupling of the starboard short section line shaft. At this time it was concluded that the injury to the starboard shafting was due to the stranding in the Inland Sea. It was also surmised that the first mishap, when the port tail shaft broke, was the cause of the injury to the other shafting on that side. It was evident that after the port tail shaft broke the engines raced considerably before the governor took effect, undoubtedly causing the fracture to the port thrust shaft and injury to the short section line shaft on the same side.

While at Yokohama the spare thrust shaft was placed on the port side and temporary repairs made to the starboard thrust shaft and short section line shaft on the same side. On the starboard thrust repairs were made by shrinking a band 4½ inches by 4 inches thick on the Verity coupling. This worked satisfactorily during the remainder of the voyage across the Pacific. From Yokohama the liner returned to Nagasaki, where, for the second time on this voyage, she entered drydock to ship the spare starboard tail shaft, which was fractured at the inboard end but otherwise intact. From Nagasaki the vessel returned direct to Puget Sound, where it was necessary to install only a new thrust shaft on starboard side, replacing that one which had done service under temporary repairs for more than 5,000 miles.

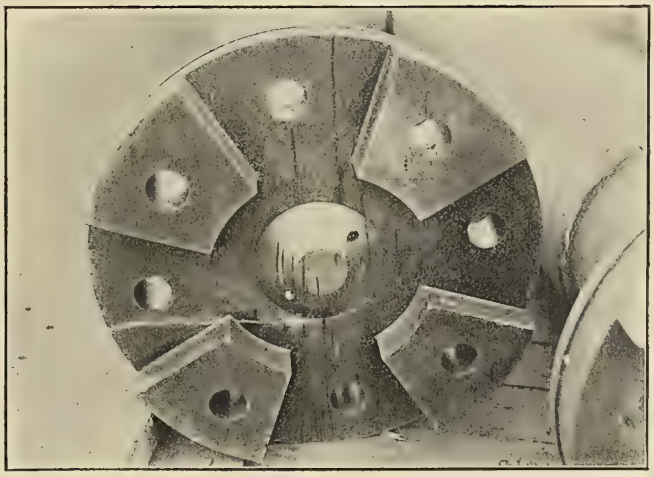


FRACTURED PART OF THRUST SHAFT, SHOWING BOLTS FOR TEMPORARY REPAIRS.



FRACTURED STARBOARD THRUST SHAFT.

PORT TAIL SHAFT BROKEN 5 FEET FROM OUTBOARD END, LOSING PROPELLER.



FRACTURED STARBOARD TAIL SHAFT, INBOARD END.

On the company's docks in Seattle are lying about 60 tons of steel shafting, this including two tail, two thrust and two short section line shafts. With the exception of the port tail-shaft, which wrenched off at the outer end, each shaft contains one or more fractures, some very slight. To the expert these cracks present the peculiarity of not having passed through the weak points in the couplings. One of the short section line shafts contains two fractures, one along the lug and the other through the coupling, it being believed that the latter developed first. The *Minnesota's* shafts are hollow, each having an 8-inch bore throughout. The tail shafts are each 37 feet long, 19 inches diameter through the steel and 21⅜ inches over the lines. Each weighs 36,603 pounds. The thrust shafts measure 14 feet in length and 18 inches diameter, each weighing 13,325 pounds. The short section line shafts are 7 feet

10 inches long by 17¼ inches diameter, and each weighs 6,295 pounds.

While returning to Yokohama on both occasions, the first time under starboard engine alone and the second time under port engine, the *Minnesota* was in exceedingly heavy weather. The second time she steamed 1,500 miles against unusually high seas. On her return from sea the second time she was in company with the Japanese liner *Sadom Maru,* which stood by until the *Minnesota's* passengers, mail and fast freight were transferred for the American side. This was no easy task, as the weather was bad and the *Minnesota* was hard to maneuver under one engine alone. This is stated to have been the first time that mails have been transferred from one liner to another in mid-Pacific.

By wireless and cable the *Minnesota's* plight was soon known to her agents in Seattle and St. Paul. When she sustained her first mishap the wireless carried the news ashore 800 miles, and it was immediately cabled to her agents on this side. On the occasion of the second accident the news was quickly known; for although she was 900 miles out from the Japanese side, within nine hours news of the mishap was known here. The *Minnesota* has been an unfortunate vessel, having had several bad breaks in her machinery. But for the fact that she has twin screws it is possible that she might have been lost before this, or at least would have cost her owners a large sum in salvage. Two years ago she broke one of her tail shafts when about 600 miles off this coast. Under the engine still intact she made the remaining distance, and at that time was docked in the Puget Sound navy drydock.

Seattle, Wash. R. C. Hill.

Another Method of Repairing a Fractured Shaft.

Editor International Marine Engineering:

Quite an interesting letter that of H. S. G., page 377 of the September issue of the journal. As stated by F. Webster, in the same issue, marine engineers are the ones who know how to do things. In fact, they *must* know, for very often it is a case of sink or swim with them, and at such a time their inventive faculties are very much alive. Too bad that H. S. G. did not have a friction coupling such as I am about to describe, for with it he could have done the job much quicker and with less labor; and, I believe, a better all-round job. Not that I discount the job as it was done, as he evidently did the best he could with the facilities at hand.

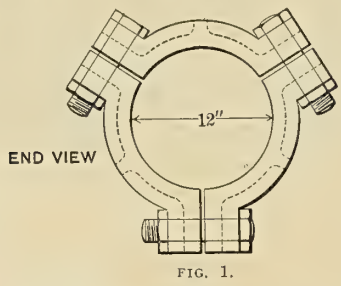


FIG. 1.

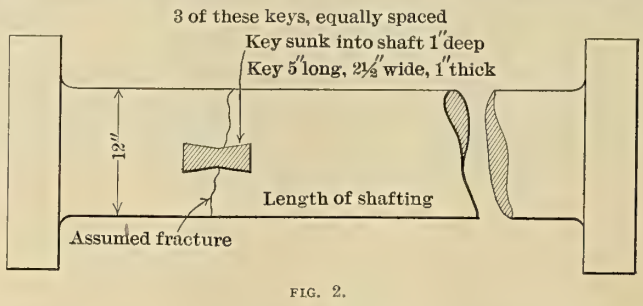


FIG. 2.

Probably the accompanying illustrations—Figs. 1 and 2—will tell the story pictorially as well as words would do. But, on second thought, a brief word explanation will not be superfluous. Fig. 1 shows a three-piece clamp or friction coupling, as it is sometimes called. It is made of cast steel, ribbed at the back, and is usually made from two and one-half to three times as long as the diameter of its bore, which is made to suit the shaft for which, in any case, it is intended. Many ships carry clamps like the one referred to, as it has proved its worth.

The clamp is placed over the fracture, which fracture is shown in Fig. 2. The three parts must be drawn up with the bolts equally, so as to have an even stress on all parts. When the clamp is properly tightened there is not much danger of the shaft slipping, especially when it is considered that a fracture seldom if ever occurs exactly at right angles to the center line of the shaft, and therefore an irregular break will assist the coupling to turn the outboard broken piece. Of course, it would be better to put in two, or preferably three sunken keys, as shown in Fig. 2. The dimensions of such keys will suggest themselves to the engineers about to use them. I merely assume a case in the illustrations and dimension the keys to suit. The keys should be slightly tapered toward the center of lengths, so as to insure the broken pieces of shaft not pulling apart.

With ratchet and drills and chisels, which all ships carry in their engineer's storerooms, the key-seats can be cut in a few hours; in the meanwhile the keys can be made by those not engaged in making the key-seats. The keys do not have to be as neatly fitted as though the job were to be permanent, for when once in place and secured by the cast steel friction clamp there is no danger of either slippage or failure of the keys to remain in their places. This kind of repair has stood the test and will, I am sure, commend itself to those who may some day require it. Charles J. Mason.

Scranton, Pa.

Cut-Off for Mid-Gear Position.

Editor International Marine Engineering:

The Stephenson link motion, which is one of the most common reversing gears, serves the double purpose of reversing the direction of rotation of the engine and of varying the point of cut-off. The point of cut-off may be changed by changing the link to some intermediate position, the effect being to hasten the cut-off and the compression and, consequently, increase the number of expansions. When the link is placed in its mid-position the engine usually stops, for the reason that the amount of steam admitted is not sufficient to overcome the resistance of the engine. The steam ports are not entirely closed, as some are inclined to think, but they may be opened an amount equal to the lead; that is, the maximum port opening for mid-position of the link is equal to the lead. The displacement of the valve, that is, the distance that the valve moves in either direction from its mid-position, is equal to the lap plus the lead. The total travel of the valve is, therefore, equal to twice the lap plus twice the lead.

With the foregoing information and the use of a diagram the point of cut-off for mid-gear position may be found. Draw a horizontal line, *a b,* to some convenient scale to represent the stroke of the engine. The circle *a c b d* then represents the crank circle. At a distance equal to the lead above the stroke line *a b,* and parallel to it, draw the line *e f,* which will be known as the lead line. Now, with a radius equal to the lead, and with the center *O* of the crank circle as a center, draw the circle *g h,* which will represent the port opening

circle, since the maximum port opening is equal to the lead. The lead line *e f* will be tangent to this circle, as shown. From the point *O*, which is the center of the crank circle, erect a perpendicular, *o c*, to the stroke line *a b*. From the lead line *e f* lay off a distance, *g j*, on this vertical line equal to the lap of the valve. Then, with the point *j* as a center, and with the lead *g j* as a radius, describe the circle *g i k* tangent to the lead line *e f*. The distance *O j* then represents the displacement of the valve for mid-gear position, since the displacement of the valve is equal to the lap plus the lead. The center *j* of the lap circle must be vertically above the center

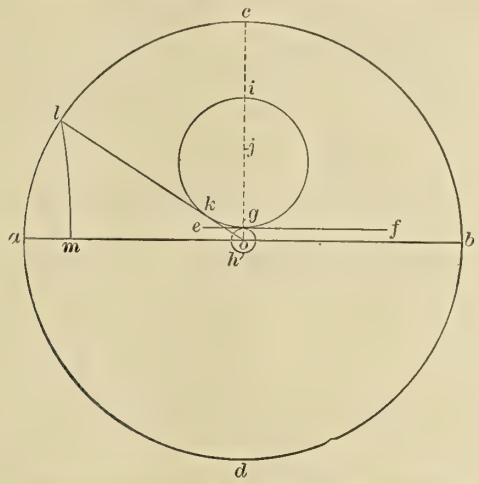


DIAGRAM FOR CUT-OFF FOR MID-GEAR POSITION.

O for mid-gear position, because if the center of the lap circle is taken either to the right or left of the vertical through *O*, and the lap circle is drawn tangent to the lead line *e f*, the displacement of the valve *O j* will be greater than the lap plus the lead.

Having located the lap circle as shown, then from the center *O* draw a radial line tangent to the lap circle at *k*, cutting the stroke circle at *l*. Then, with a radius equal to the length of the connecting rod, and with a center on the stroke line produced, draw an arc of a circle from the point *l*, and cutting the stroke line at some point as shown. The distance *a m* measured to the same scale as *a b* will be the portion of the stroke completed when cut-off takes place. The principal employed in the above diagram is the same as that employed in the Bilgram valve diagram, which is probably familiar to many of the readers of this paper. T. W. Holloway.

Scanton, Pa.

Trouble with a Capstan Motor.

Editor International Marine Engineering:

On a vessel in which electricity was employed for auxiliary purposes the anchor winch was operated electrically. In such winches and capstans there is, or should be, always some form of safety device whereby, in the event of the chain fouling, or the load becoming excessive, the motor and capstan are protected from too heavy strains. In the case considered the motor was arranged with a friction clutch, so that this would slip when the motor was subjected to an excessive load. Of course, it did not at any time allow the motor to run free, as it always maintained a certain amount of strain on the winch.

One time, when the winch was hauling the anchor the latter suddenly got caught and the motor was at once heavily loaded. Probably the clutch was dirty; at any rate it did not do its duty in slipping under the excess load, with the result that the motor was suddenly brought to a standstill and the rush of current through it damaged it very severely. The motor was probably over-fused at the time; there is a tendency on board ship, if an electric fuse blows, to strengthen it, so that it will not give any more trouble, and this sort of thing will always occur so long as all and sundry can get at the fuses. Another thing which might have been done to avoid trouble of this sort would have been to put a compounding winding on the field of the motor, which would have stiffened the field (and therefore the back electro-motive force of the motor while running) against the strain. This would, however, have made the motor more expensive, and shipowners usually do not spend too much on their electrical equipments. Yet another way to protect a motor of this sort would have been to have had a resistance, which, when the motor was overloaded, could be inserted in series with the armature by automatic switches, thus bringing the current down to limits which would not damage the armature. For this arrangement a series motor would have been required.

Probably the best cure of all, however, is the simplest; this is attention to details. However small and insignificant a part of the ship's machinery may be, it should have its turn of attention and repair. If the clutch had been systematically cleaned, and if the surfaces, when worn so that the clutch was "fierce," had been renewed, the trouble would probably not have occurred and the expense of a new armature would have been avoided. S. A. Booth.

Fracture of a Feed Pump Barrel.

Editor International Marine Engineering:

The steamship "B——" was on a voyage from Valencia, in Spain, to Liverpool. We were two days out from Valencia, and during this time the engineers experienced great difficulty in keeping a proper quantity of water in the boilers, although the feed pumps were working properly and the evaporator was going all it knew how all day. We made an external examination, but failed to discover any leakage. The evaporator was blamed for the whole trouble. The evaporator was really a very good one, and the loss of water seemed likely to continue, when, fortunately, one of the engineers grasped the bilge discharge pipe to prevent himself from falling during a heavy roll of the ship. Finding the pipe extremely hot he immediately suspected where the lost feed water was going, especially as the feed and bilge pumps were all in one casting.

The chief at once ordered the feed donkey to be started and the pump opened out, and when this was done we found a hole between the feed and bilge pumps, which we afterwards found out was due to a faulty casting. We then made a lead templet, from which we made a brass patch to cover the hole. This was bedded on and jointed up, and we then started the pump up again; but, I am sorry to say, the repair gave way after working for two days, due to it being impossible to secure the patch properly against boiler pressure. We then tried working with one pump, but failed to supply the necessary quantity of water, so we decided to attempt another form of repair. The ram was taken out of the bilge pump and a blank flange was fitted over the stuffing box. The bilge suction valve box was uncoupled and a blank flange fitted, and wood plugs were inserted in the bilge suction, and the discharge pipes were uncoupled.

As will be seen, the bilge pump was then shut off and connected to the feed pump, the leak being effectually stopped.

The after well and bilges were alternately pumped out by the after bilge pump. Upon arriving in a home port, a new feed and bilge pump casting was supplied and fitted.

Camden, N. J. F. J. S. N.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place New York
By MARINE ENGINEERING, INCORPORATED
H. L. ALDRICH, President and Treasurer
Assoc. Soc. N. A. and M. E.
and at
Christopher St., Finsbury Square, London, E. C.
E. J. P. BENN, Director and Publisher
Assoc. I. N. A.
HOWARD H. BROWN, Editor
Member Soc. N. A. and M. E.; Assoc. I. N. A.

AMERICAN REPRESENTATIVES
GEORGE SLATE, Vice-President
E. L. SUMNER, Secretary

Circulation Manager, H. N. Dinsmore, 83 Fowler St., Boston, Mass.
Branch Office: Boston, 643 Old South Building, S. I. Carpenter.

Entered at New York Post Office as second-class matter.
Copyright, 1911, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain, entered at Stationers' Hall, London.

Notice to Advertisers.
Changes to be made in copy, or in orders for advertising, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 10th of the month.

Shipbuilding Revival in the United States.

The completion of the Panama Canal in 1913 will open a new field for sea transportation in the United States which has not been paralleled in history before. Preliminary preparations to take advantage of some of the opportunities offered by this new method of carrying on commerce between the Atlantic and Pacific coasts and between the United States and Central and South American countries have resulted in the tentative calling for bids from American shipbuilders for about forty new passenger and freight steamships of large tonnage and speeds corresponding to the services required. This prospective activity in building large steamships will be accompanied by the construction of a great number of barges, tugs, lighters and shallow-draft boats for service on both the Atlantic and Pacific coasts, and particularly in Central America, where a vast amount of trade awaits the connecting link of sea transportation through the Isthmus.

The most important development of the coast-to-coast traffic by sea through the Panama Canal is the call for bids on the ocean mail service advertised by the Postmaster-General between New York and Colon, New Orleans and Colon, San Francisco and Panama, and Seattle and Panama, with calls at intermediate ports. This coast-to-coast mail service is to be maintained weekly, and will call for about fifteen ships capable of sixteen knots. The principal company, which has been incorporated for bidding on this work, considers that such a service will form but the nucleus of a rapidly-growing and most important transportation service by opening up direct connection with thousands of miles of navigable inland waters in the Mississippi Valley and in the Central American countries, together with transshipments at the canal terminals to and from the steamship lines from all other nations in the world. This sort of traffic has already been provided for by the Government by beginning the construction of piers and warehouses equipped with the necessary freight-handling appliances at the canal entrances. In this direction much can be done at the ports which are to benefit by the coast-to-coast service. Improving terminal facilities in American ports has always lagged far behind the progress made in foreign ports where the improvement of terminals has kept pace with, and more frequently preceded, the domestic development in shipbuilding and ocean transportation. This state of affairs, in view of the coming impetus in the American merchant marine, should be given prompt and careful consideration in order to make the most of opportunities.

Although shipbuilding in the seacoast yards of the United States gives promise of a substantial increase during the next few years, with equally good opportunities to follow, the outlook for the shipyards on the Great Lakes, where such large amounts of tonnage have been produced in the last decade, is not so good. The production of freighters has apparently been overdone, but there is still some indication that orders will be placed for ships of special classes, and that the lull is temporary.

Development of the Oil Engine.

Propulsion of ships is a subject prolific of countless changes and innovations in the various means available for generating, transmitting and applying power to overcome the resistance of ships. Fuels, generators, prime movers, transmission devices and the vast hoard of auxiliaries all receive due attention, and often the changing of one involves the entire readjustment of the others. It is only the result of years of experiment, trial and development that any definite type of power plant attains the state of perfection which insures increased efficiency and the desired economy in operation. The internal-combustion engine using heavy oil as fuel, or, as it is usually called, the oil engine, is no novelty, and has long held a minor place in marine work as a prime mover. Its possibilities have been widely proclaimed, and many of its features which tend toward simplicity in the whole

plant by doing away with much of the machinery and manual labor required in operating a steam plant cannot be ignored. The savings in weight and space on board ship, the thermal efficiency of the engine and the ease in handling the fuel apparently indicate a valuable saving in running expenses and an increased capacity in the ship, which mean added returns from the earning power of the vessel. It cannot be assumed, however, that such alluring possibilities of a comparatively new form of propulsion can supply a demand for it by themselves. The problems concerning the available supply and cost of the fuel, the reliability and actual efficiency of the engine as shown by practical results, and the practical construction, operation and repairs of the engines designed in large sizes for various uses need careful consideration. Fortunately much progress has been made in this direction in the last two years, particularly in Europe and Great Britain, and the reader can form some idea of its magnitude and the results to be expected from our leading article this month.

Success in the propulsion of ocean-going ships by oil engines, whether of the Diesel or similar types, will depend largely upon the knowledge and practical experience gained from the volume of this work now going through the shops of prominent builders of marine machinery. Constructional problems cannot be solved at a glance, nor can the difficulties at sea be eliminated by preliminary experiments on shore. Oil engines, if successful, require a high grade of material and the most careful workmanship by skilled mechanics who are accustomed to delicate work. Operation, upkeep and repairs at sea will require the same intelligent work, with a full knowledge of the principles and practical operation of such engines. With the rapid progress in the development of oil engines now in sight it is advisable for marine engineers to give the subject a careful study. What the engine builders and naval architect put before you in this way is not merely a matter of passing interest, but food for thought.

Improving Terminal Facilities.

The port of Antwerp is one of the most progressive European ports, and the description of some of its terminal features, which is published elsewhere in this issue, is worthy of examination by those connected with shipping interests in large American ports where very little progress has been made to increase the transshipping facilities for handling freight from the railroads to the steamship lines. Not all of the Antwerp equipment is modern, but its usefulness has been proved, and the application of the same principles to the old-fashioned docks where freight transferring is done principally by manual labor could be adopted with profit. The harbor arrangements and dock facilities at Antwerp have been steadily improved, and in connection with them government warehouses of ample capacity and convenient location have been installed. Freight is easily transferred by mechanical means from the hold of a steamship upon trucks or railroad cars, or placed on platforms where consignments can be sorted and the re-handling reduced to a minimum. The cranes are movable, so that they may be placed directly opposite the hatches on the steamship and swing the freight to the cars, which can be driven directly under the frames. Also, the government warehouses are fitted with freight-handling appliances, so that the time and cost of handling freight are both reduced.

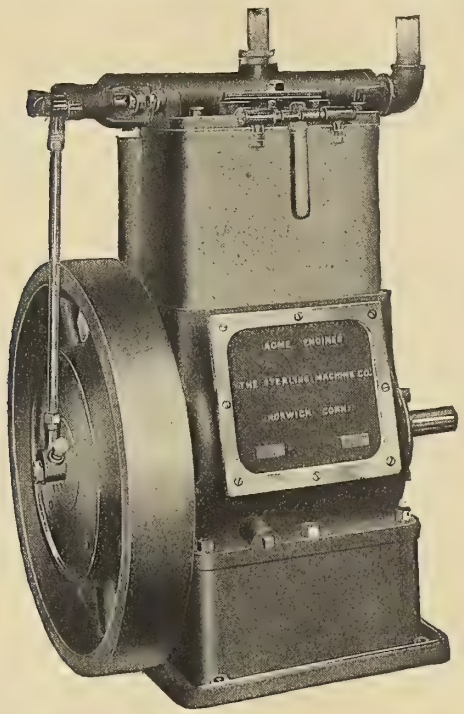
To secure the best efficiency in handling freight mechanically at terminals, both speed and immunity from damage are necessary. Whatever gain is made by quick transference of the freight from the ship to the pier may be lost if much rehandling and transference by hand labor are necessary. Special forms of dock cranes and transporters are needed in most cases, depending upon the conditions to be met. Perhaps the worst obstacle in the improvement of American ports is the control of water frontage by private interests, where little help can be expected from municipal or State action. Whoever owns the water frontage in a harbor will, naturally, develop it for his own exclusive interests, and many things which would benefit the port as a whole are disregarded. There are some ports where government control is possible, and it is here that the more important improvements can be made which will benefit all of the corporations who use the harbor as a terminal. With the rapid increase in the American merchant marine which is expected, it is undoubtedly true that there will be more direct and progressive action on the improvement of ports, bringing about the same facility and economy that are secured at Antwerp.

While many arrangements for transporting freight must conform, in a measure, to the requirements imposed by the kind of construction used in existing freight steamships, yet, as has been brought out before by the discussion in these columns, there is much to be gained by co-operative work between naval architects, shipbuilders and the designers of mechanical appliances for handling freight at steamship terminals, so that improvements can be embodied in the design of vessels which will simplify the adaptation of the cargo-transferring devices and permit a ship to be loaded or unloaded in a shorter period of time and with less damage to the cargo. Of course, any change in ship design is but one feature in the question of transporting freight at terminals, for there are many other local conditions which affect the delivery of cargo from ships to its destination; but the design of a freight steamship is of much more importance, and much can be made of it to secure better results even in the best equipped terminals, such as Hamburg, Liverpool and Antwerp.

ENGINEERING SPECIALTIES.

Acme Steam Engines.

The Acme engine, formerly manufactured by the Rochester Machine Tool Works of Rochester, N. Y., and now by the Sterling Machine Company of Norwich, Conn., has been on the market for the past twenty years and has been improved, from time to time, to meet the demands of the day for a rugged, simple and economical unit. These engines are of the vertical, two-cylinder, single-acting enclosed type, with a balance rocking valve, and are splash lubricated. They are built in three series of sizes. This range of sizes covers all the applications to which these engines are especially adapted. Because of the extreme simplicity of construction, the type of valve which adjusts itself to wear, the large bearing surfaces which are thoroughly well lubricated at all times by a splash of oil, they are especially well suited in marine service for



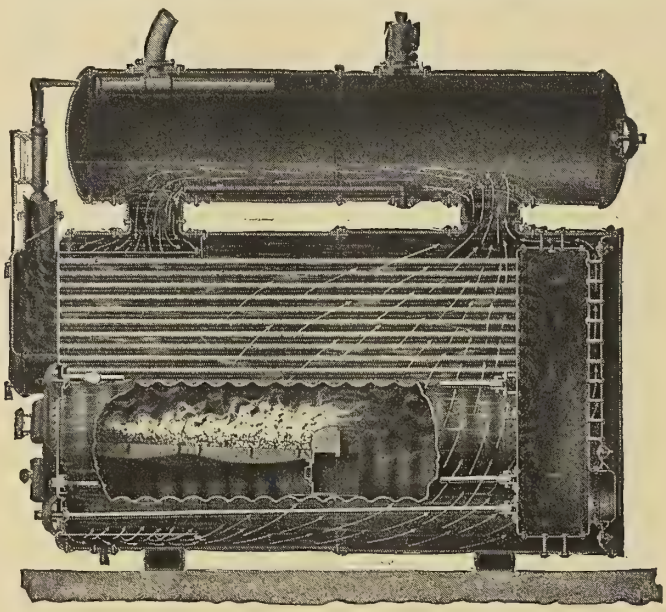
driving lighting sets, ammonia compressors, ventilating fans, etc.

The character of internal construction shows the influence of automobile engine practice in many of the details. For example, the crank shafts are drop-forged and ground to very accurate size, the connecting hods are of the popular I-beam section, bushed with bronze at both ends; the bearing cap on the crank end being held in place by castle nuts and cotter pins, as is common in automobile work; the piston rings are of the diagonal cut type, two being placed above the wrist pin and one below. These rings are re-turned after cutting and ground to accurate size. The valve is a simple one-piece casting, which is ground on the outside to fit a very accurately bored chamber, and is fastened to the extended valve stem with a cross key in just the same way that the ordinary Corliss valve is fastened. A further point of considerable interest is the matter of automatic cylinder relief valves, which are built into the cylinder heads to relieve any water that might otherwise cause damage. The governor is of a very simple type, consisting of four main pieces, the action of the weights being modified by means of a hardened roller which travels in a milled arc. The entire governing mechanism is contained in an oil pocket, only the pin to which the lower end of the valve rod is connected being extended through; and, further, inasmuch as this mechanism is on the outside of the fly wheel it is readily accessible. There are but two grease cups requiring attention, all other surfaces being amply lubricated by the internal splash. Provision is also made in the base of the engine for the elimination of the condensation which may collect, and the leakage from the valve stem stuffing box falls down into the engine base through the vent pipe at the end of the engine. The entire series of engines is built with new and accurate jigs on the interchangeable plan.

Robb-Brady Boiler.

The Robb Engineering Company, of South Framingham, Mass., and Amherst, Nova Scotia, is marketing the Robb-Brady Scotch marine boiler.

The boiler has two drums, which are connected by two necks—the lower being entirely filled with water, while the upper drum is for steam space. The lower drum is filled with tubes. The combustion chamber is cylindrical and of a



diameter nearly equal to that of the larger shell. The tubes take the place of through staybolts. The main point claimed is that the arrangement results in better circulation than is obtained in the usual Scotch boiler. This is obtained by compelling the hot water from the steam drum to flow down the front neck and around the shell through the annular space, the water from this space emptying below the furnaces and replacing the hot water and steam which take the shortest path to the top, passing to the steam drum through the rear neck, thus increasing the economy of the boiler, as this rapid circulation keeps all heating surfaces clear, resulting in a more uniform expansion and eliminating the necessity of a special pump to increase the circulation. This boiler is made in sizes from 50 horsepower up to 300, and for pressure up to 225 pounds.

Maxim Boiler with Allison Economizer and Arch Drum.

The Maxim boiler is a watertube boiler which has no flat surfaces, stayed parts, headers or hand doors, a construction which, it is claimed, insures entire freedom for expansion and contraction, and makes the boiler suitable for high-pressure requiring minimum floor space. Three manholes give access to all drums and both ends of every tube. The alleys are wider than the tubes, so that any tube can be replaced without disturbing the others. The lower main drum and blow-off pipes are thoroughly protected from the action of

the fire. Wrought steel construction supports the boiler independent of the brickwork. Both the furnace and combustion chambers are of brick, and they are of ample size to insure good combustion.

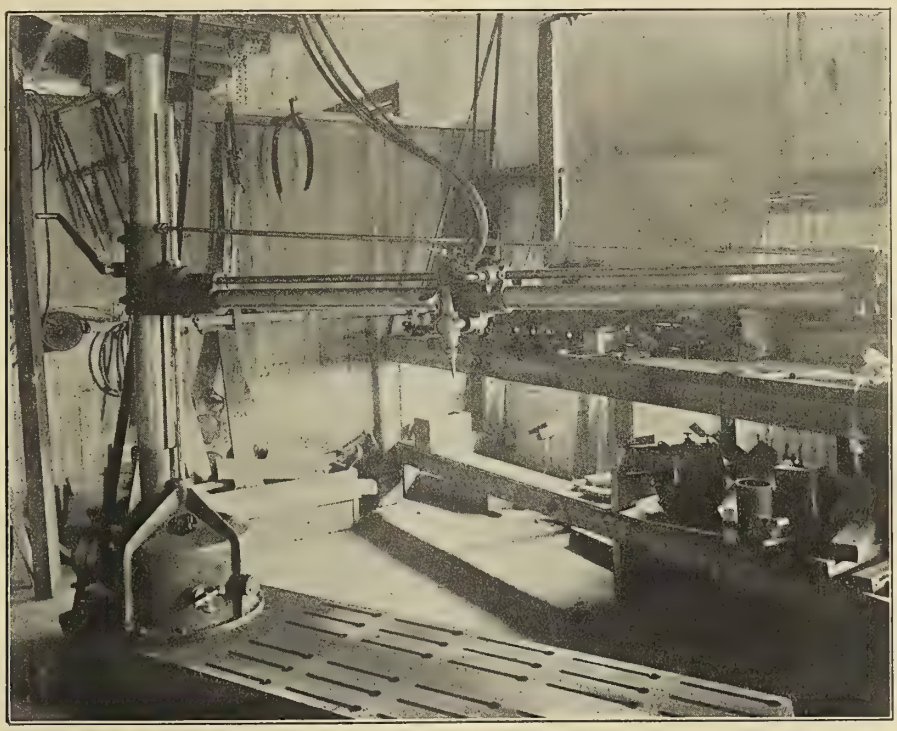
In the Allison patent economizer or fourth pass the gases pass down while the water rises. A partition in the lower main drum opposite the baffle prevents the feed water from getting into the boiler circulation until it has been heated and purified in the economizer tubes. This, it is claimed, insures low stack temperature and a clean boiler. On test it was demonstrated that with steam at a temperature of 357 degrees F. the temperature of the escaping gases was only 312 degrees F. This boiler is sold by Allen Stirling, Drexel building, Philadelphia, Pa.

Acetylene Welding and Cutting Machine.

A machine for welding and cutting material by means of an acetylene torch has recently been brought out by the Davis-Bournonville Company, of 90 West street, New York City.

The illustration which we give shows the tool set up in a shop. It is in appearance, in a general way, very much like a radial drill of light construction.

By means of a friction drive in the column and gears on the driving shafts, the screw seen above the extended arm is made to actuate the sliding saddle which travels on the arm, and which carries the torch to which the oxygen and acetylene are brought by flexible tubes, which are of the ordinary form. The torch can, of course, be replaced by a cutting jet. The feed of the torch can be varied from 3 to 24 feet per minute,

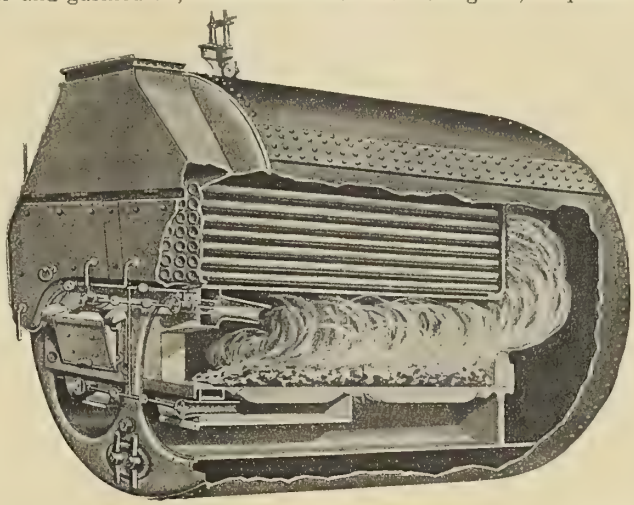


and work 6 feet long can be welded. The work is clamped on the table. The arm can be raised or lowered by means of a rack and pinion. A tight and loose pulley is used in connection with an ordinary countershaft for driving.

The Gregory Patent Coal-Oil Apparatus.

A device for preventing smoke, accomplishing the complete combustion of inferior grades of coal, anthracite, bituminous and lignites, as well as peat, etc., and increasing the economy of boilers has been placed on the market by the Direct Gas Fuel, Ltd., 17 Victoria street, London, S. W., and in America by the Davis Volatile Fuels, Ltd., Land Title building, Philadelphia, Pa.

The apparatus consists essentially of means for admitting air and gasified oil, both above and below the grate, in quanti-



ties which can be regulated to give complete combustion of the fuel in the furnace. When applied to Scotch marine boilers the portion of each furnace nearest the furnace door is fitted with a cast iron air-heating chamber resting on the dead plate, with an opening through the same corresponding with the size and shape of the furnace opening. Air is admitted directly into this chamber through two air holes, 3 inches in diameter, on each side of the furnace door in the furnace front. Underneath each fire grate and extending for half the length of the furnace another chamber is fitted, forming an air duct to that portion of the grate where the draft is least effective. The draft is admitted to this chamber through a delivery pipe, on the inner end of which is attached a nozzle of special form fitted with a small steam jet to assist the draft to the front half of the grate. Either compressed air or steam can be used. The admission of air through the delivery pipe is regulated by a small valve, so that the proper quantity can be admitted to insure the combustion

of whatever kind of fuel is being used. Inside the air-heating chamber, immediately over the furnace door, is a specially constructed nozzle pointing into a discharge pipe fitted close to the top of the furnace, the mouth pointing slightly down towards the fire. Radial pipes 2 inches in diameter branch from each side of the nozzle in the upper heating chamber, and pass around the furnace opening, forming a connection to the air chamber below the grate. A steam pipe of small bore is fitted through the furnace front into the nozzle, so that a small jet of steam or compressed air may be introduced when desired.

The discharge of steam through the nozzle produces a partial vacuum in the nozzle, so that air is drawn from the air chamber below the grate through the branch pipes, and in passing through the air chamber at the top of the furnace becomes heated. The steam mixing with the heated air forms a gas, and the gas thus produced is projected from the nozzle through the deflected discharge pipe into the furnace, and combining with the other gases as it passes over the fire it ignites and assists in the combustion of the fuel. In addition to the steam or compressed air jet, a small pipe is fitted for the supply of oil, and a quantity of oil may be introduced into the nozzle with the steam. This action gasifies the oil and assists materially in consuming the gases from the fire, which would otherwise pour out of the stack in the form of smoke. The oil supply can be regulated as desired, but it has been found that the average proportion of oil should be about 2 or 3 percent of the coal used.

A number of steam vessels have been fitted with this device, and under test on a vessel which used coal at the rate of 10 tons per day a saving of about 2 tons of coal per twenty-four hours' steaming was shown to have been obtained by the use of the Gregory apparatus.

TECHNICAL PUBLICATIONS.

Annual Report of the Mercantile Marine Bureau for the Year 1909-1910. Department of Communications, Tokyo, Japan.

This compilation is most instructive and seems thorough to the last degree. It takes up tonnage, shipbuilding, inspecting, casualties and many other sub-divisions of marine work, also the matter of subsidies granted various lines, giving their earnings and expenses, which show a profit in most cases. The dimensions of vessels, together with the horsepower, are given, and, taken altogether, the issue is well worth studying.

Essential Factors in the Formation of Producer Gas, Bulletin No. 7, Bureau of Mines. By J. K. Clement, L. H. Adams and C. N. Haskins.

The Bulletin is of a scientific character, and will be of interest to engineers engaged in gas-producer and gas-engine work. Copies may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

Self-Taught Mechanical Drawing in Elementary Machine Design. By F. L. Sylvester, M. E. Size, 5¼ by 7¼ inches. Pages, 325. Illustrations, 218. The Norman W. Henley Publishing Company, New York.

All through this work the author has stuck closely to the highly practical. The mathematics needn't frighten anyone. They are extremely simple, clear and can be understood by anybody that can multiply, divide and subtract. It is much more than a book just on learning to draw and design, as it goes into the fundamentals of physics clearly and concisely. It gives excellent examples of various accepted styles of mechanical contrivances, and it would seem to us that the apprentice should welcome the book most heartily. The only thing that we criticise is the author's idea of making self-study easy. We are not of the opinion that anything that is easily obtained sticks well. A little hard digging is good. The ambitious boy that wants to know something can learn, but there is a never-ending lot who are mentally ambitious and thoroughly lazy. This class want their study in capsules to swallow at a single gulp, and we hardly think that the class is worthy of consideration, but any determined young man in the mechanical trade can read Mr. Sylvester's book with advantage.

The Naval Pocket Book. By Rollo Laird Clowes. Size, 3¾ by 5 inches. Pages, 1,029. Illustrations, numerous. N. Thacker & Company, 2 Creed Lane, London, E. C. Price, $2.00.

It is quite impossible for the man who is interested in marine matters to be without this book. Every newspaper in the world should have it, and, in fact, the information contained therein is of general interest, as even with the peace movements of late the power to make people be good is needed, and every country takes interest in its navy, and from *The Naval Pocket Book* the important facts concerning it can be learned.

Practical Applied Electricity. By David Penn Moreton. Size, 5 by 7¼ inches. Pages, 414. Illustrations, 323. Numerous tables. The Reilly & Britton Company, Chicago, Ill. Price, $2.50.

There is no place where training is better obtained for those who desire to impart information than through the evening schools. Here the pupil is anxious not merely to get through but to learn, and he is a sponge in absorbing knowledge. Mr. Moreton, who is the author of *Practical Applied Electricity,* has had this training, and certainly he is to be congratulated on what he has turned out, and while he says he may not be considered "at all times logical," he must be considered, we think, at all times highly practical, and that is the object of his work. The use of something visible in explaining electricity is most happily chosen, as, for instance, the hydraulic analogy of electrical currents helps the beginner to understand, through his eyes, which are, in fact, our greatest teachers, and Mr. Moreton has most admirably used this idea in his explanation.

The Slide Rule—A Practical Manual. By Charles N. Pickworth. Size, 5 by 7½ inches. Pages, 118. Illustrations, 34. New York: D. Van Nostrand & Company. Price, $1.00.

The value of this little book on the slide rule is largely proved by the fact that it has passed through eleven editions, and in the present issue it has been revised and extended. There is not much to be said on the subject that is new. The significance of various gage points is commented upon, and some new styles of slide rules are described. It seems from our observation that a person once started on the study of the slide rule very soon "gets the habit," and its practical use is really endless, and to the busy engineer or draftsman it is of the very greatest help.

COMMUNICATION.

Notes on the Strength of Ship Columns.

Editor International Marine Engineering:

The following notes may have interest in view of the recent addition of comprehensive column tables to the general specifications for building ships of the United States navy. The explanation in which Mr. R. E. Anderson, in the October and December, 1910, issues of International Marine Engineering, foreshadowed their appearance, is also alluded to.

CLASSES OF COLUMNS.

Warship columns may be divided into two classes—structural and local.

Structural columns are those which support the main

structure of the ship, and which are as much a part of that structure as the frames and beams.

The scantlings of structural columns are not worked out in detail, but are a matter of judgment and experience, as the maximum load they may have to carry is unknown. So far attempts to find these loads by Dr. Bruhn's method of least work has not furnished quantitative results.

Local columns, which form the second class, are those which support local loads, such as capstan, gun and other foundations.

It is here that formulæ can, in general, be applied, but the thick deck plating and heavy overhead girders now obtaining in warships form such rigid abutments that to neglect end fixing is absurd.

COMPARISON WITH BEAMS.

Putting on one side the direct stress in columns and shear in beams, we have for the same form of elastic surface a perfect analogy. Take, however, actual loadings—simple compression for the column and uniform loading for the beam—and consider the ends fixed.

Assuming a high value of L/r we may apply Euler's method. Let W be the equilibrating load for a column of length l, and M_o, M_e, M_x the bending moments at ends, middle of length, and a section distant x from one end, respectively the deflection at the x section being y, we have

$$M_x = E\,I\frac{d^2y}{dx^2} = -\,Wy + M_o$$

The solution is $y = \frac{M_o}{W} + A\,Cos.\sqrt{\frac{W}{E\,I}}\,x + B\,Sin.\sqrt{\frac{W}{E\,I}}\,x$

When $x = o$, $y = o$ $\Big\}$ $\therefore A = -\frac{M_o}{W}$ When $x = o$, $\frac{dy}{dx} = o$ $\Big\}$ $\therefore B = o$

When $x = \rho$, $y = o$ & $\frac{dy}{dx} = o$ $\Big\}$ $\therefore$ $Cos.\sqrt{\frac{W}{E\,I}}\,\rho = 1$, $A\,Sin\sqrt{\frac{W}{E\,I}}\,\rho = o$ $\Big\}$.

Solving $\sqrt{\frac{W}{E\,I}}\,\rho = 2\,\pi$, *or* $W = \frac{4\,\pi^2\,E\,I}{\rho^2}$.

Again by substituting, we have:

$$M_x = Cos.\sqrt{\frac{W}{E\,I}}\,x\,M_o.$$

$\therefore$ When $x = o$, or ρ. $M_x = M_o$

& When $x = \frac{\rho}{2}$. $M_x = -\,M_o = M_e$.

We thus see that fixing the ends reduces the bending moment at middle to one-fourth of that for free ends, and that the bending moments at the ends are equal to that at middle.

For beams, we know that fixing the ends reduces the bending moment at middle to one-third of that for free ends, while the bending moment at ends are twice that at middle.

END FIXING.

Watertight-bulkhead testing affords a good criterion as to end fixing where the stiffeners are regarded as beams.

A large number of tests were analyzed by the writer, the results of which were given in a paper read before the North East Coast Institute of Engineers and Shipbuilders, and it was there shown that for watertight bulkheads having good, solid abutments the degree of constraint of the stiffeners was 60 percent.

Taking into account the above comparison of distribution of bending moment, it seems reasonable to expect for local columns a good degree of constraint. In general, experiment supports this conclusion.

THE GOVERNMENT COLUMN TABLES.

Consider these two excerpts from the instructions for proportioning compressive members:

1. "In determining the safe loads no distinction is to be made between fixed, flat, pin hinged and round ends." * * *

2. "For pin-end compressive members * * * the radius of gyration used should be that corresponding to the probable plane of failure, provided this radius of gyration be not greater than twice the least radius of gyration of the cross section."

In actual practice we find that structural columns, not being "figured out," are not affected—a divergence of 1 : 2 for similarly placed columns existing in recent warships.

The Navy Department tables, taken as self-explanatory, do not meet the case of local columns, inasmuch as they entirely neglect end fixing, and in consequence demand scantlings two to four times heavier than necessary.

Mr. Anderson's justification for his neglect of end fixing seems to rest partly upon the supposed incompetence of draftsmen in shipyards aspiring to government work, and partly upon one or two opinions which are really not applicable.

For instance, Mr. C. C. Schneider (Quebec Bridge Report), when speaking of the "elastic deformation of the truss," was not referring to a 60-pound N. S. deck to which a column was firmly bolted, nor did Moncrieff, in speaking of the difficulties of estimating the restraint, infer that it should be neglected.

The second excerpt may be written thus: Pinning the ends of a column may be regarded as fixing them in a plane parallel to the center line of the pins to any extent up to 100 percent.

Here Mr. Anderson errs on the other side, for a single pin, unless a very vicious affair, would hardly produce absolute constraint.

The innovation of using nominal ultimate loads—loads which are purely hypothetical, and tax the imagination to conceive—is apt to lead to some confusion.

The upper limit of the range of nominal factors given is 9, which corresponds to a true factor of 5.4, and which would barely cover the case of a column likely to be much fatigued.

THE ROOT FORMULA.

Mr. Anderson eschews the Rankine-Gordon formula, and considers it the "least accurate of all." This is most interesting, as only last year Dr. Lilly, one of the highest authorities, gave as his opinion that it was the most satisfactory of all column formulæ. Between the limits usually taken —namely, $L/r = 20$ and $L/r = 200$—the Rankine-Gordon formula is the most reliable.

For mild steel, rounded ends, the formula is

$$\frac{W}{A} = \frac{21.4}{1 + {}^1/_{7500}\left(\frac{\rho}{r}\right)^2}\ \text{(tons per square inch)}.$$

Between the limits stated the writer finds a close agreement with the tables, excepting that the loads there given are less for the lower values of L/r. Now, the Rankine-Gordon formula is on the safe side for short columns, so the Moncrieff curve droops too much. It would seem that the eccentricity factor of Mr. Anderson does not take into account the fact that eccentricity is more marked the shorter the column.

As regards rationality, there is nothing to choose between either of the above formulæ.

Mr. Anderson is to be complimented on having made a determined onslaught on the rather nebulus data pertaining to strength of columns; but even while admiring the result, one wonders if system, like fire, though a "good servant," may not prove a "bad master."

A. J. Murray.

Quincy, Mass.

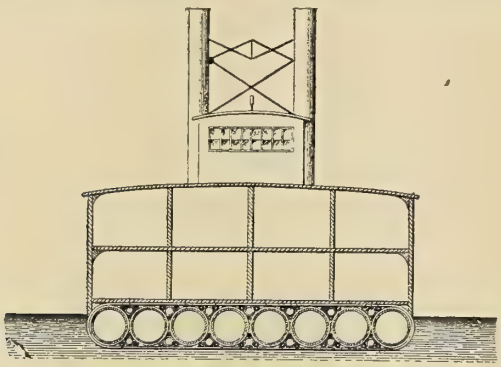
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

995,557. FREIGHT VESSEL. AUGUST J. PEEBLES, OF MOLSON, WASH.

Claim 1.—A freight vessel having a plurality of storage tanks extending side by side lengthwise thereof, and buoyant tubes associated with



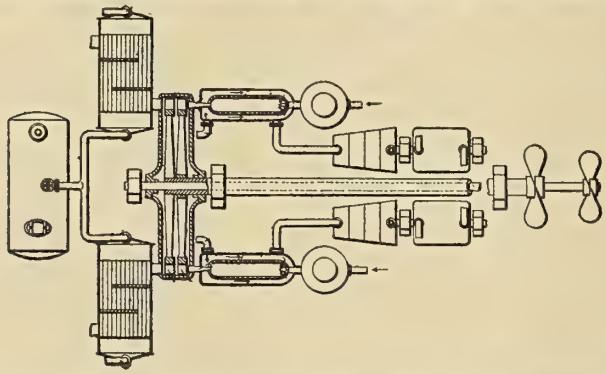
and located in the intervening spaces above and below said tanks. Four claims.

995,562. PROPELLING-WHEEL. JOHN PLEWES, OF KIMBERLY, ONT., CANADA.

Claim 1.—A propelling wheel comprising a hub, four blades each having a straight front edge radiating from the center of the hub, a peripheral edge concentric with the axis of rotation and the back edge cut away or hollowed in compound curve form in proximity to the hub and with a straight edge from the end of the curve to the concentric outer edge, and each blade increasing in width from the hub to the concentric outer edge, so that a line drawn at any point across the width of the blade is equal in length to the radial distance to such line and the pitch of each blade being so arranged as to have an even graduated decrease from the hub to the outer edge. Two claims.

996,324. PROPULSION APPARATUS FOR SHIPS, BOATS, AND THE LIKE. SEBASTIAN ZIANI de FERRANTI, OF HAMPSTEAD, LONDON, ENGLAND.

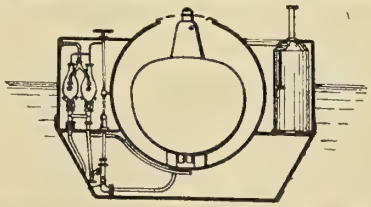
Claim 1.—In combination, a turbine having one or more bladed members, a plurality of guides coacting with the blades of said members to



form a plurality of paths for the working fluid of varying operative lengths, together with means for supplying working fluid to any of said paths at will. Eight claims.

998,970. FLOATING DOCK. CESARE LAURENTI, OF SPEZIA, ITALY, ASSIGNOR TO SOCIETÀ ANONIMA FIAT-SAN GIORGIO, OF SPEZIA, ITALY.

Claim 1.—In a floating dry dock, the combination of a cylindrical watertight receptacle adapted to entirely inclose a vessel, means for admitting



a vessel to said receptacle, and caissons supporting said receptacle. Thirteen claims.

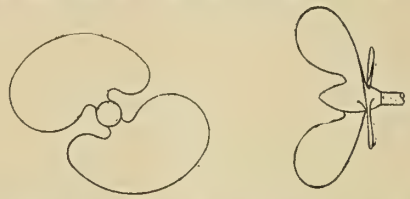
999,795. FOLDING ANCHOR. DANIEL A. JONES, OF OSHKOSH, WIS.

Claim 1.—A folding anchor, comprising a shank having arms and stock members pivotally connected thereto, and means operatively connected to the arms and to the stock members to cause the said arms and the said stock members to move to folded or unfolded position and said means also extending through the upper end of said shank for connection with a cable. Eleven claims.

British patents compiled by G. E. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 21 Southampton Building, W. C., London.

19,396. PROPELLERS. F. H. TREWEEK, FALMOUTH.

By this invention the maximum thrust per horsepower is obtained. In shape the blades are nearly semi-circular, but radially shorter at the front than at the rear edge, and they are joined to the boss with the smallest connection consistent with strength to allow free access of the



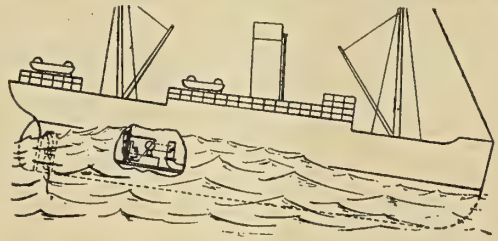
water to the blades. The pitch of the blades is small at the front edge and gradually increases towards the rear edge, thus gradually imparting velocity to the water as it passes through it. An axial section gives a curve inclining, and its concave side facing backwards and both the inclination and the concavity gradually increase from the front to the rear edge to minimize the effect of centrifugal force which tends to throw the water off the blades.

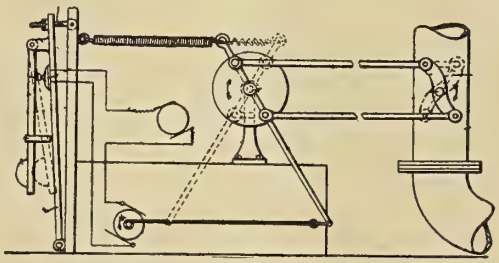
20,667. INDICATING THE POSITION OF SUNKEN VESSELS. J. B. BLAINE, S. R. EAST AND J. G. STEVENS, NEW ZEALAND.

When the vessel sinks, a buoy, contained in a stand on deck, floats to the surface and indicates its position in daylight by means of a bell, and at night by means of a pilot light in the chamber. There is a compartment for documents, etc. The chain is made in, say, fathom lengths connected by swivels to prevent twisting and to indicate the depth at which the vessel is submerged.

23,443. PREVENTING THE RACING OF MARINE ENGINES. F. TANNER, H. J. HARRIS, AND H. BURT, NEW ZEALAND.

A throttle valve in the main steam pipe has a lever upon its spindle, which is actuated by a spring so that the valve is normally kept open to its full extent. A weighted pendulum, which is adjustable to suit the

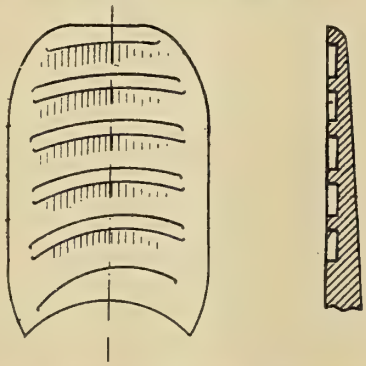




loading of the ship, is arranged to close contact in an electric circuit when the stern of the ship rises in the air. A motor in this circuit is thus brought directly into operation, and by actuating suitable gearing closes the throttle valve. A buffer may be used in connection with the pendulum to prevent shock.

17,935. SCREW PROPELLERS. J. HALLIDAY, LIVERPOOL.

This refers to the type of propeller blade provided on its thrusting surface with a series of projecting ribs. The invention consists in eliminating the helical twist of the thrusting faces of propeller blades



and in providing the plane thrusting faces with transverse grooves sunk below the normal surface. The face view of the blade is approximately rectangular with rounded corners as distinct from the usual elongated oval.